HILO AREA
COMPREHENSIVE STUDY
VOLUME 2 OF 4

Hilo Breakwater Modification

DRAFT
SURVEY REPORT AND
DRAFT ENVIRONMENTAL
IMPACT STATEMENT

APRIL 1983

US Army Corps of Engineers
Pacific Ocean Division

DEPARTMENT OF THE ARMY
US ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858

HILO AREA COMPREHENSIVE STUDY, HAWAII

A DRAFT SURVEY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

FOR

BREAKWATER CHANGE

APRIL 1983

HONOLULU ENGINEER DISTRICT

SYLLABUS

This is a draft survey report of the feasibility for improving the existing Federal project at Hilo Harbor, Hawaii. The initial requests for this study were Resolutions 144 (1973) and 480 (1975) by the Hawaii County Council. In 1976, the US Congress authorized the study. The Honolulu Engineer District initiated the Hilo Area Comprehensive Study that year. This report addresses the Hilo breakwater and the bay's water quality.

The existing Federal project, a 35-foot-deep harbor and a 10,080-foot-long breakwater, was completed in 1930. The breakwater does not meet current design criteria and requires major repair work. It was determined in the Hilo Harbor, Deep Draft Navigation Improvements study that a 2,000-foot breakwater, with a different alignment, could replace the outer 7,500 feet of the existing breakwater.

This report recommends deauthorization of the outer 7,500 feet of the existing breakwater and replacement with a 2,000-foot breakwater along a different alignment. This plan compared to the existing project would provide a net savings to the Federal Government of $417,000 per year in maintenance and repair costs. The plan includes construction of a hydraulic model to test the effect of the proposed breakwater change on tsunami impacts on shore. The plan would not be implemented if the model tests showed that tsunami impacts would be aggravated. This plan would have a total investment cost of $19,923,000 and would have a significant positive effect on the environment. It will restore the environmental conditions on Blonde Reef, a major coral habitat, to permit the repopulation of corals. The existing project destroyed the breaking wave condition on the reef. The breakwater prevented the natural outflow of silt and other pollutants to the open ocean causing them to settle out and smother the living corals. The proposed plan would remedy this problem for the length of the breakwater which has had the most adverse impact.

VOLUME II. HILO BREAKWATER

A DRAFT SURVEY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

TABLE OF CONTENTS

Title	Page
AUTHORITY	1
PURPOSE AND SCOPE	1
PRIOR STUDIES, REPORTS AND EXISTING WATER PROJECTS	2
PLAN FORMULATION	2
Existing Conditions	2
Future Conditions (Without A Project)	3
Problems and Opportunities	3
Objectives	3
Constraints	4
ALTERNATIVES	4
Available Measures	4
Nonstructural	4
Structural	4
Development of Alternative Plans	4
EVALUATION OF THE PLAN	6
PLAN SELECTION	6
SELECTED PLAN DESCRIPTION	6
Components	6
Design and Construction	6
Operation and Maintenance	7
Accomplishments	7
Summary of Economic, Environmental and Other Social Effects	7
IMPLEMENTATION	7
Institutional Requirements	7
Federal and Non-Federal Responsibilities	12

VOLUME II. HILO BAYFRONT BEACH (CONT)

TABLE OF CONTENTS (CONT)

Title	Page
SUMMARY OF COORDINATION, PUBLIC VIEWS AND COMMENTS	12
DRAFT ENVIRONMENTAL IMPACT STATEMENT	EIS-1

LIST OF FIGURES

Figure No.	Title	Follows Page
1	VICINITY PLAN	1
2	HILO BAY	1
3	HILO BREAKWATER - EXISTING CONDITION	2
4	PLAN A	5

LIST OF TABLES

Table No.	Title	Page
1	PLAN A COSTS	5
2a	EXISTING & FUTURE CONDITIONS WITHOUT THE ALTERNATIVE PLANS	8
2b	ALTERNATIVES WHICH WERE CONSIDERED BUT NOT DEVELOPED INTO PLANS	9
2c	ALTERNATIVES AND EFFECTS	10
2d	EXISTING OR EXPECTED FEDERAL AND NON-FEDERAL PROJECTS WHICH MAY AFFECT THE RECOMMENDED PLAN	11

SUPPORTING DOCUMENTATION

ENGINEERING, DESIGN, AND COST	D-1
GEOLOGY	G-1
ECONOMICS	E-1

AUTHORITY

The authority for this interim survey report is Section 144 of the Water Resources Development Act of 1976 (Public Law 94-587). Section 144 states:

> The Secretary of the Army, acting through the Chief of Engineers, in cooperation with the State of Hawaii and appropriate units of local government, shall make a study of methods to develop, utilize, and conserve water and land resources in the Hilo Bay Area, Hawaii, and Kailua-Kona, Hawaii. Such study shall include, but not be limited to, consideration of the need for flood protection, appropriate use of flood plain lands, navigation facilities, hydroelectric power generation, regional water supply and wastewater management facilities systems, recreational facilities, enhancement and conservation of water quality, enhancement and conservation of fish and wildlife, other measures for environmental enhancement, and economic and human resources development. Based upon the findings of such study, the Secretary of the Army, acting through the Chief of Engineers, shall prepare a plan for the implementation of such findings which shall be compatible with other comprehensive development plans prepared by local planning agencies and other interested Federal agencies.

PURPOSE AND SCOPE

This volume presents a plan for implementation of the study findings to reduce the repair and annual maintenance costs of the Hilo breakwater and to restore and improve the overall water quality of Hilo Bay at Hilo, Hawaii (Figure 1). This volume of the survey report addresses these issues of the study authority, and is part of the Hilo Area Comprehensive Study.

The investigations described in this report affect Hilo Harbor (Figure 2). Investigations were made on reducing the immediate and future maintenance and repair requirements for Hilo Breakwater; measures or combinations thereof capable of satisfying such needs; the accompanying economic, environmental, and social considerations; and coordination with concerned agencies and the public. These studies provide the depth and detail required to determine plan feasibility.

After review and approval by the Board of Engineers for Rivers and Harbors, the final report of the Chief of Engineers will be forwarded to the Secretary of the Army who will obtain the views of the Office of Management and Budget and transmit the report to the Congress. If the Congress concurs with the report's findings and authorizes the project, funds will be requested to perform advanced engineering and design work. Construction would be initiated after assurances of local cooperation are furnished.

This report is a decisionmaking document containing an environmental impact statement and supporting documentation covering engineering, design, cost, geology, and economics.

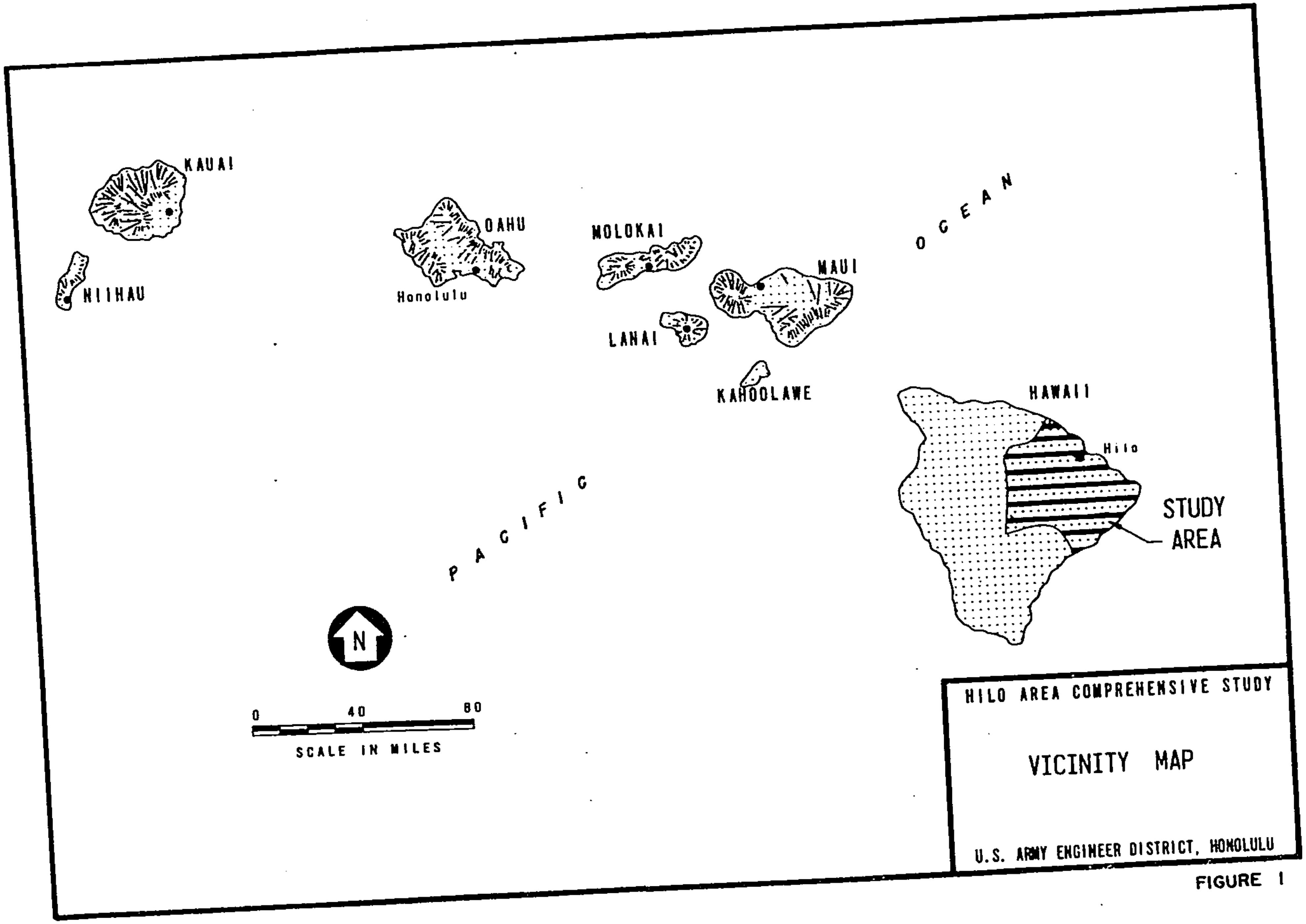
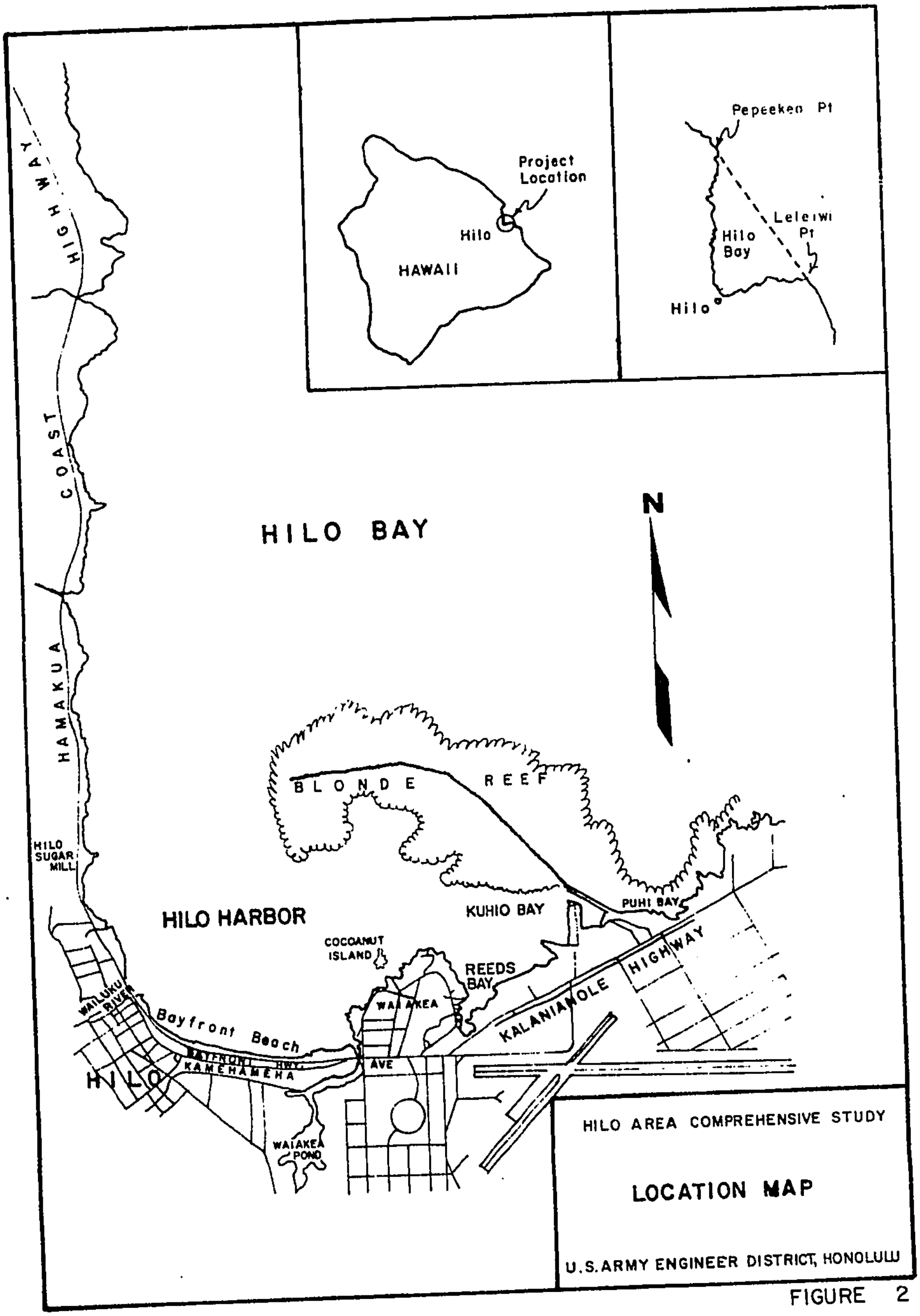

KAUAI
NIIHAU
OAHU
Honolulu
MOLOKAI
LANAI
MAUI
KAHOOLAWE
HAWAII
Hilo
STUDY AREA
OCEAN
PACIFIC
N
0
40
80
SCALE IN MILES
HILO AREA COMPREHENSIVE STUDY
VICINITY MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 1



HILO AREA COMPREHENSIVE STUDY

LOCATION MAP

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 2

PRIOR STUDIES, REPORTS, AND EXISTING WATER PROJECTS

The existing deep-draft harbor at Hilo is an authorized project which includes a rubblemound breakwater 10,080 feet long; an entrance channel 35 feet deep; and a turning basin 1,400 feet wide, 2,300 feet long, and 35 feet deep. The project was authorized under the River and Harbor Acts of 2 March 1907, 25 July 1912, and 3 March 1925. The project was completed in July 1930. Sixty percent of the breakwater was seriously damaged during the 1946 tsunami and repairs were completed in 1948. Later breakwater repairs were completed in 1968, 1975 and 1981.

A tsunami protection project was authorized by the 1960 River and Harbor Act. A post-authorization study was completed in 1967. The study found that protective works at a cost of $60 million would be feasible. However, local government rejected the plan and its $10 million local cost-sharing requirement. The project was deauthorized in 1977.

A study to determine the feasibility of modifying Hilo Harbor to prevent surge was authorized by House Resolution 739 in 1967. The results were not fully conclusive but suggested that surge is correlated with short-period waves generated by North Pacific storms.

A study addressing the Deep-Draft Navigation component of the Hilo Area Comprehensive Study is being finalized. It recommends deepening of the existing Federal habor project at Hilo.

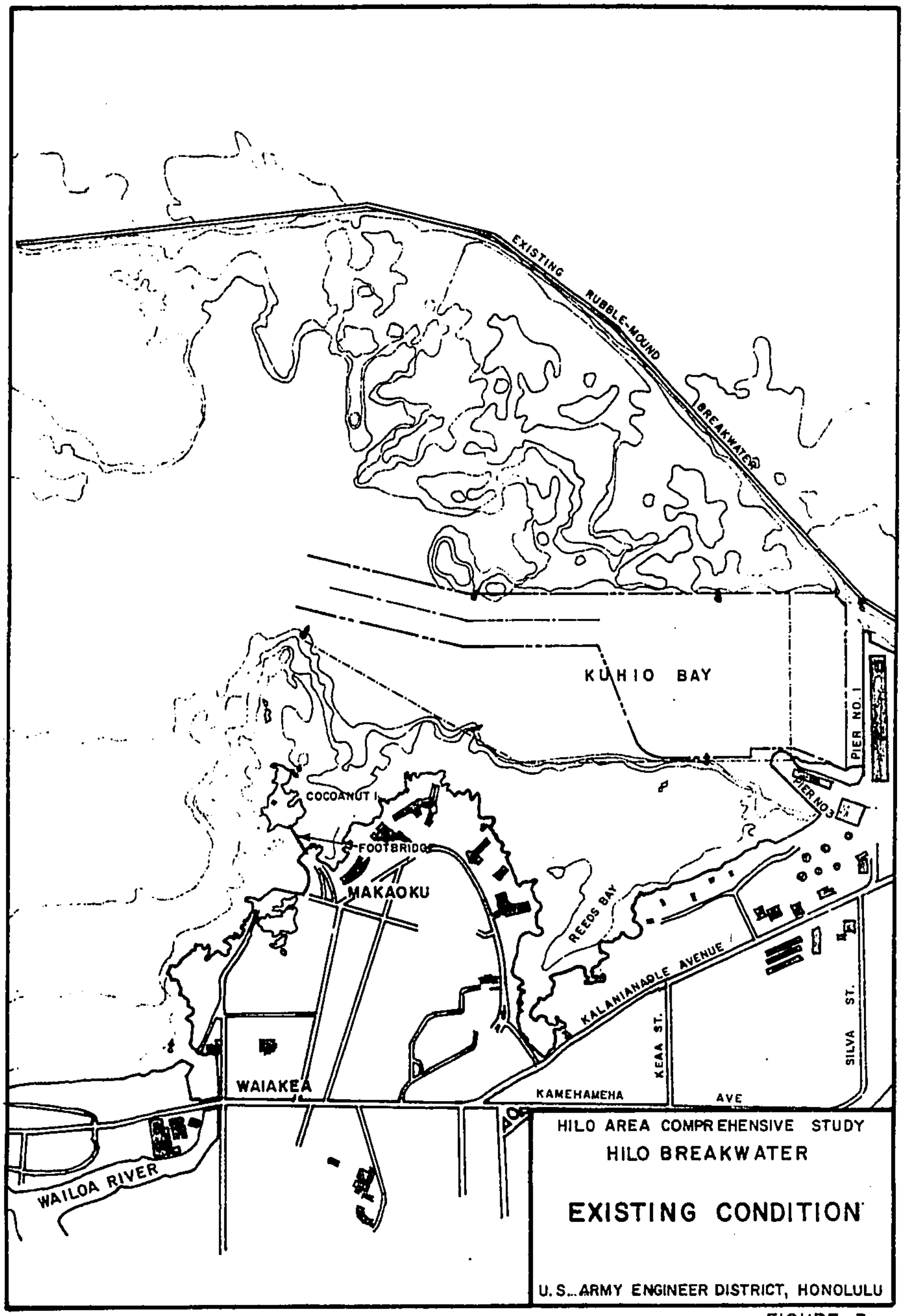
PLAN FORMULATION

Existing Conditions

Hilo is the urban, commercial and government center for Hawaii County and is located on an island of more than 4,000 square miles with a population of about 92,000 people. Forty-six percent of the population resides in Hilo. It contains one of the County's two major airports and the primary commercial harbor (the third largest in the State). Most of the island's general cargo and petroleum inshipments and sugar and molasses outshipments pass through Hilo.

The cargo volume at the commercial port has averaged over 1 million tons annually for the past decade. An upward trend continues, but major increases in cargo throughput are not predicted unless significant changes to the existing economic situation develop, for example, establishment of a manganese processing industry. A passenger vessel calls weekly at Hilo.

The Hilo breakwater (Figure 3) was constructed in increments, beginning in 1908 and completed in 1930. The existing length of the breakwater is 10,080 feet, and is constructed on Blonde Reef in water depths of about 10 to 20 feet. The breakwater is of rubblemound construction, originally with a single layer of 8-ton minimum armor stone on the crest and seaward slope to a depth of -3 feet. The crest elevation is +11 feet with a seaward slope of 1.5 horizontal to 1 vertical. The breakwater has been repaired and rehabilitated over the years. The landward end has recently been improved with tribar concrete armor units.



HILO AREA COMPREHENSIVE STUDY
HILO BREAKWATER

EXISTING CONDITION

U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 3

The breakwater has considerably reduced wave energy along the Hilo Harbor shoreline, particularly the prevailing trade wind wave energy from the northeast and east. The breakwater is essentially impermeable and has had detrimental effects on water quality in the harbor and on Blonde Reef by reducing circulation and increasing bay water residence time. The elimination of breaking wave energy and transport across the reef has reduced the exchange rate within the harbor and increased sedimentation on Blonde Reef.

The Corps of Engineers is responsible for the maintenance of the Federal project. A 700-foot section of the breakwater directly seaward of Pier 1 was repaired with concrete armor units placed on the seaward slope and buttressed by concrete ribs on the breakwater crest at a cost of about $2 million. Additional work is expected to be done during the next few years to repair the entire breakwater, which is over 50 years old and does not meet current design criteria.

Future Conditions (Without A Project)

The breakwater will require extensive repair work to bring it up to current design standards. Annual maintenance will continue. The problems caused by the restricted circulation of fresh seawater over Blonde Reef and parts of the bay will continue.

Problems and Opportunities

There are three problems associated with the Hilo Breakwater: (1) It requires extensive repairs to meet current design criteria; (2) there are high annual maintenance costs due to its long length and substandard condition; and (3) it reduces circulation of fresh seawater over Blonde Reef and to parts of Hilo bay.

The existing Hilo breakwater was designed and constructed over 50 years ago, and requires extensive repairs. The 10,080-foot-long breakwater requires high annual maintenance expenses which are directly proportional to its length. These annual maintenance expenses will exist throughout the useful life of the Hilo harbor.

The breakwater restricts circulation and flushing of Blonde Reef and parts of Hilo bay. This has caused sediments to be deposited on the reef and has made the bay more turbid. Eventually, the sediments will destroy the portion of reef behind the breakwater by smothering living corals and covering the hard bottom with soft silt. The need for extensive breakwater repair presents a unique opportunity to revise the design to obtain improved bay water quality and coral habitat on Blonde Reef.

Objectives

The following objectives were established for this study:

a. Reduce the repair and annual maintenance costs of the Hilo breakwater without adversely affecting the safety of ships using Hilo harbor.

b. Improve the water quality of Hilo Bay and coral resource of Blonde Reef.

c. Avoid aggravation of tsunami hazards in Hilo Bay.

Constraints

Several constraints were identified prior to formulating alternative plans.

a. Hydraulic model tests are required to determine if tsunami runup elevations on land would be significantly affected by modifications of the breakwater.

b. Improvements to the quality of the bay's water are constrained by the existing project breakwater which restricts circulation and reduces flushing by fresh ocean water. Circulation improvements are crucial to improving the bay's quality since all significant point sources of pollution have been shut off and the State has a nonpoint water quality management plan in effect.

ALTERNATIVES

Available Measures

The following measures are available to meet the planning objectives:

Nonstructural. There are no nonstructural measures available which meet the planning objectives.

Structural. Structural measures applicable to achieve the objectives for this study include reductions in length or elevation of the existing breakwater, and the construction of a shorter replacement breakwater along a more efficient alignment.

Existing Breakwater Modification. To reduce the repair and annual maintenance cost, deauthorization of the outer 7,500 feet of the existing Hilo breakwater is an alternative measure. Implementation of this plan would require the construction of a 2,000-foot breakwater along a new alignment. Variations of this plan which would accelerate the environmental benefits include breaching the outer 7,500 feet of breakwater at regular intervals or removing armor stone to a crest elevation of 3.0 feet. Methods of modification include the following:

a. Allow the breakwater to deteriorate naturally.

b. Remove the breakwater rock and use it to construct the new shorter breakwater.

c. Breach the breakwater at specified intervals.

Development of Alternative Plans.

One alternative plan was formulated which meets the national economic development objective and contributes to environmental quality. This plan has several possible variations due to the method or modification ultimately chosen to alter the existing breakwater. However, these variations are not significantly different from each other and do not warrant treatment as separate alternatives.

PLAN A: BREAKWATER CHANGE

Description. This plan (Figure 4) requires deauthorization of the outer 7,500 feet of the existing breakwater and construction of a new 2,000-foot section with a different alignment. The new shorter breakwater would be as effective in protecting the commercial port as the existing breakwater, but would give substantial savings in repairs and maintenance. Table 1 shows the estimated costs and benefits.

TABLE 1, PLAN A. COST AND BENEFITS ($)

Project First Cost (20% Contingency)		$15,574,000
Engineering, Design, Supervision and Administration (E&D, S&A)		3,245,000
Interest During Construction (IDC) 12-month Construction Period		1,104,000
TOTAL INVESTMENT COST		$19,923,000
Interest & Amortization (0.07823 or 7-5/8%) on the Total Investment Cost		1,559,000
Annual Operation and Maintenance (O&M) Cost		57,000
TOTAL AVERAGE ANNUAL COSTS		$1,616,000
Average Annual Benefits		2,065,000
Benefit-to-Cost Ratio		1.3
Net NED Benefits		449,000
Cost Apportionment	Non-Federal	Federal
Project First Cost	None	$15,574,000
E&D, S&A	None	3,245,000
IDC	None	1,104,000
TOTAL INVESTMENT COST		$19,923,000

Impact Assessment. This plan would have a significant positive enhancement to Hilo Bay's water quality by improving mixing and to coral habitat by flushing Blonde Reef. Temporary turbidity would occur during construction. An investigation of the impacts on tsunami runup would require model studies. The plan will shorten the historic Hilo breakwater. This plan would save the Federal Government $417,000 annually by reducing the estimated expenditures for maintenance and repair of the existing project.

Mitigation Requirements. None.

Implementation Responsibilities. The Corps would provide overall management for implementation and the State would be responsible for all local requirements.

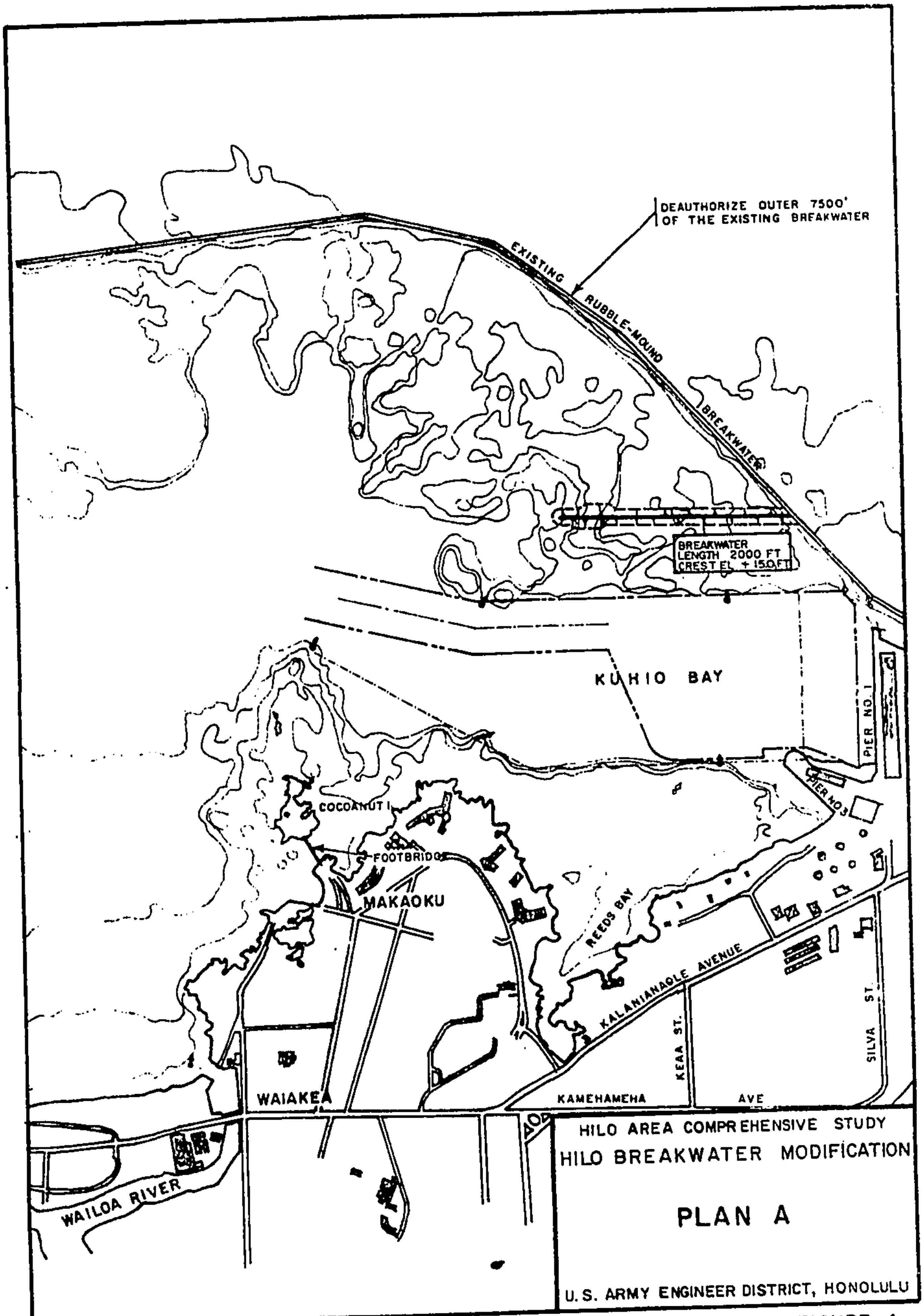

DEAUTHORIZE OUTER 7500'
OF THE EXISTING BREAKWATER
EXISTING RUBBLE-MOUND BREAKWATER
BREAKWATER
LENGTH 2000 FT
CREST EL +15.0 FT
KUHIO BAY
PIER NO. 1
PIER NO 3
COCOANUT I
FOOTBRIDGE
MAKAOKU
REEDS BAY
KALANIANAOLE AVENUE
KEAA ST.
SILVA ST.
KAMEHAMEHA AVE
WAIAKEA
WAILOA RIVER
HILO AREA COMPREHENSIVE STUDY
HILO BREAKWATER MODIFICATION
PLAN A
U.S. ARMY ENGINEER DISTRICT, HONOLULU

FIGURE 4

Cost Allocation. None.

Public Views.

a. Federal Agencies: The USF&WS, the USNMFS, and the USEPA favor this plan.

b. Non-Federal Agencies: The State Division of Fish and Game favors this plan. Questions were raised about the effect on tsunami wave runup heights which might be caused by breakwater alterations.

EVALUATION OF THE PLAN

It should be noted that there is basically one plan, which is to construct a 2,000-foot breakwater along a new alignment and to deauthorize the outer 7,500 feet of the existing breakwater. There are various ways of dealing with the abandoned section. These include removal of armor stone, breaching or natural deterioration. A final decision would be made after the model studies are completed.

PLAN A: BREAKWATER CHANGE (FIGURE 4). This plan has a benefit-to-cost ratio greater than unity (BCR = 1.3). It would reduce the annual maintenance and repair costs of the breakwater. Deauthorization of the outer 7,500 feet of the existing breakwater would provide positive environmental impacts in the long term to Blonde Reef and the bay's water quality. The shortening of the historic breakwater will have visual impacts.

PLAN SELECTION

Plan A was tentatively selected as the final plan because it meets the planning objectives and makes a considerable contribution to the national objective of economic development through a major cost savings. There is also a significant long term enhancement of the Hilo Bay environment.

SELECTED PLAN DESCRIPTION

Components

The tentatively selected plan includes the following components (Figure 4):

a. Construction of a 2,000-foot breakwater.
b. Deauthorization of the outer 7,500 feet of existing breakwater.

Plan A will reduce the overall annual maintenance and repairs for the breakwater, and in the long term enhance the coral habitat of Blonde Reef as well as the bay's water quality.

Design and Construction

After the completion of the hydraulic model studies, the design work as well as construction could be accomplished in two years. No significant problems are anticipated.

Operation and Maintenance

Maintenance requirements will be reduced with the shortening of the Federal project breakwater.

Accomplishments

Plan A provides a more efficient breakwater alignment, which directly results in an overall reduction in the annual maintenance and repair costs for the Federal project.

Deauthorization of the outer 7,500 feet of the existing breakwater will in the long term provide significant positive impacts to the coral habitat of Blonde Reef and the bay's water quality.

Summary of Economic, Environmental and Other Social Effects

SELECTED PLAN (PLAN A)

Economics

Total Investment Cost	$19,923,000
Annual Maintenance	57,000
Benefit-to-Cost Ratio	1.3

Environment

- o Temporary turbidity during construction.
- o Significant positive long-term effects.
- o Visual impact from change in profile of the historic breakwater.

Social

- o No significant impacts.

Tables 2a, 2b, 2c, 2d summarize and display the effects of with and without project conditions.

IMPLEMENTATION

Institutional Requirements

Following authorization by Congress, the Honolulu Engineer District would perform final preconstruction engineering and design work. The District would administer construction. The Division of Harbors, Department of Transportation, State of Hawaii is the local sponsor and responsible administrator for operation of Hilo Harbor.

BREAKWATER CHANGE

TABLE 2a

EXISTING AND FUTURE CONDITIONS
WITHOUT THE
ALTERNATIVE PLANS

	Existing	Future
DESCRIPTION	The existing breakwater is 10,080 feet long and is constructed on Blonde Reef in water depths of about 10 to 20 feet. The existing conditions are substandard and need extensive repair.	The breakwater will remain essentially the same, in terms of its function and length; however, major repair work may change its appearance with the greater use of concrete units.
PROBLEMS	High repair and annual maintenance costs of the breakwater; degradation of water quality; and continued tsunami hazards.	Annual repair and maintenance costs will continue at an estimated average annual cost of $2.5 million over a 50-year period while the bay water quality will continue to degrade.
OPPORTUNITIES	Reduction of the high repair and annual maintenance costs of the breakwater. In the long term, improved bay water quality and coral habitat growth on Blonde Reef.	None available without the project. The situation will remain basically unchanged.

BREAKWATER CHANGE

TABLE 2 b.

ALTERNATIVES WHICH WERE CONSIDERED BUT NOT DEVELOPED INTO PLANS 1/

Measures	Effects	Reason for Not Proceeding Further
Inner Harbor Protection Breakwater and Deepening Plan. Construction of two rubblemound breakwaters; an entrance channel 40 feet deep, 2,200 feet long, and 440 feet wide; and a turning basin 40 feet deep and 1,800 feet long by 1,400 feet wide.	Would worsen the environmental conditions in inner Hilo Harbor.	This plan has a benefit-to-cost ratio less than unity (BCR = 0.5) and therefore was rejected as infeasible. It also makes a net deduction to the NED and EQ accounts.
Chamber of Commerce Plan. Construction of new fill, roads and revetments for 100 acres of fast land. The turning basin and entrance channel would be deepened to 40 feet.	Negative impacts on the natural marine environment.	Has a benefit-to-cost-ratio less than unity (BCR = 0.1). It also makes deductions to the NED and EQ accounts.

1/ Discussed in the Hilo Harbor Survey Report - Deep-Draft Navigation Improvements, January 1982.

BREAKWATER CHANGE

TABLE 2c

ALTERNATIVES AND EFFECTS

Measure	EFFECTS NED	EFFECTS OTHER
Deauthorize the outer 7,500 feet of the existing breakwater. Construct a new 2,000-foot-long section with a different alignment.	This plan has a benefit-to-cost ratio greater than unity (1.3), and will improve water quality in the harbor and bay in the long term. Recolonization of Blonde Reef.	**Economic** Total Investment Cost $19,925,000 Annual Maintenance 57,000 Benefit-to-Cost Ratio 1.3 The plan would constitute savings in repair and maintenance costs of about **Environmental** Temporary turbidity during construction. Significant positive long-term effects. Visual impact from change in profile of the historic breakwater. **Social** No significant impacts.

BREAKWATER CHANGE

TABLE 2d

EXISTING OR EXPECTED
FEDERAL AND NONFEDERAL PROJECTS
WHICH MAY AFFECT THE
RECOMMENDED PLAN

Project	Interactions		
	Economic	Environmental	Physical
FEDERAL			
Reeds Bay Small Boat Harbor	No effect.	No effect.	Final plan for the breakwater modification includes model testing to prepare final design for best alignment.
Bayfront Beach	No effect.	May decrease turbidity in Hilo Bay.	Final plan for the breakwater modification includes model testing to prepare final design for best alignment.
NONFEDERAL			
None			

Federal and Non-Federal Responsibilities

All construction costs would be borne by the Federal Government since cost savings accrue directly to it. Maintenance would be done by the Federal Government as in the existing project.

Model Tests

As a prerequisite to implementation of the plan, hydraulic model tests would be performed to determine the tsunami elevations onshore with the various schemes of altering the breakwater. The plan would be implemented following successful model tests.

SUMMARY OF COORDINATION, PUBLIC VIEWS AND COMMENTS

At the most recent public meeting in September 1981, the public supported the plan and the objectives of improving coral habitat and the bay's water quality. They were concerned that tsunami impacts on the shoreline not be aggravated and were agreeable to accepting the results of hydraulic model tests on this point.

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

DRAFT
ENVIRONMENTAL IMPACT STATEMENT
BREAKWATER MODIFICATION
HILO AREA COMPREHENSIVE STUDY

The responsible local cooperating agency is the State of Hawaii Department of Land and Natural Resources, Division of State Parks, Outdoor Recreation and Historic Sites.

The responsible lead agency is the US Army Engineer District, Honolulu, Hawaii.

The US Fish and Wildlife Service is a cooperating federal agency.

Information, figures and displays referred to in the main report and appendices are incorporated as a part of this Environmental Impact Statement.

Abstract: As part of the continuing Hilo Area Comprehensive Study, the possibility of modifying the Hilo Breakwater was investigated in an effort to save federal funds required for annual maintenance. The plan involves construction of a new breakwater 2,000 feet long to protect Hilo Harbor, and deauthorizing of the outer 7,500 feet of the existing breakwater. Model studies will be conducted to determine the effect of breakwater removal on tsunami runup. If found to be adverse, the project will be cancelled. Over the long term, the plan would have a beneficial effect on the water quality of Hilo Bay.

SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY 21 Aug 1983.

If you would like further information on this environmental impact statement, please contact:

Dr. James E. Maragos, Chief
Environmental Resources Section
US Army Engineer District, Honolulu
Building T-1
Fort Shafter, HI 96858
Phone: (808) 438-2263

EIS
TABLE OF CONTENTS

Title	Page
COVER SHEET	
TABLE OF CONTENTS	EIS-1
SUMMARY	EIS-3
NEED FOR AND OBJECTIVES OF THE ACTION	EIS-7
ALTERNATIVES, INCLUDING THE PROPOSED ACTION	EIS-8
AFFECTED ENVIRONMENT	EIS-12
Environmental Conditions	EIS-12
Significant Resources	EIS-13
Natural Hazards	EIS-13
Volcanic Hazards	
Riverine and Tsunami Flood Hazards	
Endangered Species	EIS-14
Endangered and Migratory Waterbirds	EIS-14
Estuaries	EIS-14
Marine Resources	EIS-15
Water Quality	EIS-15
Sedimentation and Sediment Quality	EIS-16
Air Quality	EIS-17
Noise	EIS-17
Historic Resources	EIS-17
ENVIRONMENTAL EFFECTS	EIS-18
Social	EIS-18
Recreation	EIS-18
Natural Hazards	EIS-18
Volcanic Hazards	
Tsunami and Riverine Flood Hazards	
Endangered Species	EIS-18
Humpback Whale	
Hawksbill Turtle and Green Sea Turtle	
Migratory Waterbirds	EIS-19
Estuaries	EIS-19
Marine Resources	EIS-19
Coral	
Fish	
Water Quality	EIS-19
Noise Quality	EIS-20
Historic Resources	EIS-20

TABLE OF CONTENTS (Cont)

Title	Page
PUBLIC INVOLVEMENT	EIS-21
BIBLIOGRAPHY	EIS-28
LIST OF PREPARERS	EIS-30
APPENDIX A, Section 404(b)(1) Evaluation	A-1
APPENDIX B, Recreation and Natural Resources	B-1

1. SUMMARY

1.1 MAJOR CONCLUSIONS AND FINDINGS. Only one plan was evaluated in the Hilo Area Comprehensive Study, Breakwater Improvement Study. This was plan A - Deauthorization.

TABLE 1. PLAN FEATURES

Plan A	Deauthorize the outer 7,500 feet of the existing breakwater and construct a new 2,000-foot breakwater to protect the commercial harbor.
Plan B	No action (this is not a plan alternative, but is so labeled for ease of discussion of impacts).

Plan A is designated the National Economic Development Plan since its benefit to cost ratio is greater than 1.0.

No wetlands or floodplains are involved. Ocean disposal is not involved, but Section 404 of the Clean Water Act does apply. The State Historic Preservation Officer feels that the effect may be adverse because changing the breakwater would alter the breakwater visual elements. No prime agricultural lands are located within the project area.

1.2 AREAS OF CONTROVERSY. Possible adverse impact on the historic aspects of the breakwater.

1.3 UNRESOLVED ISSUES.

a. Tsunami Effect. It is not known at this time what effect modification of the breakwater will have on a tsunami wave. If the project is approved, modeling studies will be conducted on the selected plan to determine the plan effect on tsunami waves. If it is determined that removal or modification of the breakwater would increase the magnitude or severity of a tsunami, the project will be modified to eliminate that possibility or terminated.

1.4 RELATIONSHIP TO ENVIRONMENTAL REQUIREMENTS: (See Table 2).

TABLE 2. RELATIONSHIP OF THE PLANS TO ENVIRONMENT PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS

Federal Statutes	Plan A	Plan B
American Folklore Preservation Act	N/A	N/A
Anadromous Fish Conservation Act	N/A	N/A
Antiquities Act	N/A	N/A
Archaeological Resources Protection Act	N/A	N/A
Bald Eagle Act	N/A	N/A
Clean Air Act	Full	N/A
Clean Water Act (See Section 6.2)	Partial	N/A
Coastal Zone Management Act (See Section 6.2)	Partial	N/A
Endangered Species Act (See Section 6.2)	Partial	N/A
Estuaries Protection Act	N/A	N/A
Federal Environmental Pesticide Control Act	N/A	N/A
Federal Water Project Recreation Act	Full	N/A
Fish and Wildlife Coordination Act	Full	N/A
Historic Sites Act of 1935	N/A	N/A
Land and Water Conservation Act	N/A	N/A
Migratory Bird Conservation Act	Full	N/A
Migratory Bird Treaty Act	Full	N/A
Marine Mammal Protection Act	Full	N/A
Marine Protection, Research and Sanctuaries Act (See Section 6.2)	N/A	N/A
National Historic Preservation Act (See Section 6.2)	Partial	N/A
National Environmental Policy Act	Full	N/A
Native American Religious Freedom Act	N/A	N/A
Resource Conservation and Recovery Act	N/A	N/A
Rivers and Harbors Act	N/A	N/A
Submerged Lands Act	Full	N/A
Surface Mining Control & Reclamation Act	N/A	N/A
Toxic Substances Control Act	N/A	N/A

TABLE 2. RELATIONSHIP OF THE PLANS TO ENVIRONMENT PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS (Cont)

State and Local Policies (Cont)	Plan A	Plan B
State Conservation District Use Application Permit (See Section 6.2)	Non-compliance	N/A
County General Plan	Full	N/A
State Land Use Plan	Full	N/A
Required Federal Entitlements (Permits)		
None required		

NOTES:

a. Full (Full Compliance). Having met all requirements of the statute, Executive Order or other environmental requirements for the current stage of planning (either pre- or post-authorization).

b. Partial (Partial Compliance). Not having met some of the requirements that normally are met in the current stage of planning. Partial compliance entries should be explained in appropriate places in the report and/or EIS and referenced in the table.

c. Non-Compliance. Violation of a requirement of the Statute, Executive Order, or other environmental requirement. Non-compliance entries should be explained in appropriate places in the report and/or EIS and referenced in the table.

d. N/A (Not applicable). No requirements for the statute, Executive Order or other environmental requirement for the current stage of planning.

2. NEED FOR AND OBJECTIVES OF THE ACTION.

2.1 STUDY AUTHORITY. The study of Breakwater Improvements in Hilo Harbor is conducted under Section 144 of the Water Resources Development Act of 1976. The Act authorizes a study of methods to develop, utilize and conserve water and land resources in the Hilo Bay area, including the consideration of the need for navigation facilities, for enhancement and conservation of water quality and fish and wildlife, for environmental enhancement and for economic and human resources development. The recommendations shall be compatible with other local comprehensive development plans and plans of other interested Federal agencies.

2.2 PUBLIC CONCERNS.

a. Local residences and agencies have expressed a need to improve water quality in Hilo Bay. The turbid waters and accumulated vegetative trash on the bayfront beach reduce recreational aesthetics and discourage water contact recreation. Fishermen complain of low recreational catches, and commercial fishing in the bay has declined. The bay is presently recovering from 75 years of sewage and industrial discharges, but contaminants are still present in the harbor sediments. Hilo Harbor breakwater reduces water exchange and circulation in the bay, induces heavy sedimentation which eliminates hard bottom habitat, and creates a two-layered water body by trapping freshwater discharged into the bay by springs and rivers.

b. Local residents do not wish to see tsunami hazards aggravated and believe that the breakwater provided some protection from past tsunamis.

2.3 PLANNING OBJECTIVES.

a. Reduce the repair and annual maintenance costs of the Hilo breakwater without adversely affecting the safety of ships using Hilo Harbor.

b. Improve water quality, fish habitat, and water-contact recreation in Hilo Bay.

c. Prevent any aggravation of tsunami hazards in Hilo Bay.

3. ALTERNATIVES, INCLUDING THE PROPOSED ACTION.

3.1 PLANS ELIMINATED FROM FURTHER STUDY.

3.2 WITHOUT CONDITION (NO ACTION).

(The No Action alternative has been labeled Plan B for comparative purposes.)

3.3 PLANS CONSIDERED IN DETAIL. Only one plan has been considered, Plan A. This Plan would deauthorize the outer 7,500 feet of the existing breakwater and construct a new breakwater approximately 2,000 feet long, approximately prependicular to the existing breakwater, to protect the commercial harbor. Details of construction of the new breakwater will be developed during post-authorization studies. These studies will include hydraulic modelling to determine the effects of breakwater modification on tsunamis in Hilo Bay, and to recommend the appropriate type of modification to the existing breakwater. Possible modifications include:

a. Removal of the breakwater rock along the entire 7,500 feet to a depth to be determined by the model studies.

b. Removal of rock to create one or several gaps in the breakwater, allowing the remainder to deteriorate naturally.

c. Allow the entire 7,500 feet to deteriorate naturally.

The environmental impacts of these, or other possible modifications, will be addressed in a supplemental environmental impact statement as a part of the post-authorization studies. It is anticipated that the major difference between the possible modifications will be the timing of the associated impacts.

3.4 COMPARISON OF ALTERNATIVE IMPACTS. (See Table 3)

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS

Resource	Plan B, and Base Condition	Plan A
Recreation		
Beach Parks	Mooheau Park eroding	No effect
	Bayfront Park eroding canoeing	"
	Wailoa River Park	"
	Liliuokalani Gardens and adjacent areas	"
	Coconut Island	"
	Banyan Drive shoreline	"
	Reed's Bay swimming	"
	Baker's Beach	"
	Radio Bay	"
	Radio Bay Park	"
Surfing	Coconut Island area (1)	No effect
	Wailuku River Mouth (3)	"
	Tip of Hilo Breakwater (1	"
Fishing	Hilo Breakwater	Eventual improvement; depending on modification selected
	Shoreline areas	No effect
Boating	Wailoa River shoaling	No effect
	Radio Bay	"
	Reed's Bay	"
Natural Hazards		
Volcanic	High risk	No effect
Tsunami	Very high risk	Unknown, to be determined by model studies.
Endangered Species		
Humpback Whale (endangered)	No critical habitat in harbor, seasonal migration offshore.	No effect
Hawksbill Turtle (endangered)	No critical habitat seen in harbor, possibly feeding.	No effect
Green Sea Turtle (threatened)	No critical habitatd seen in harbor possibly foraging.	No immediate effect. Eventually may increase foraging areas.

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS (Cont)

Resource	Plan B, and Base Condition	Plan A
Estuaries		
Waiakea Pond	Brackish Water	No effect
Wailoa River	"	No effect
Wailuku River	"	No effect
Terrestrial Area	None	None created
Marine Resources		
Blonde Reef	16% coral cover, 220 acres.	Eventual revitalization, depending on fate of breakwater.
Coconut Island Reef	10% coral cover 40 acres.	No effect
Fishery Resources	Recreational value high. Number of fish species high.	Eventual improvement, depending on fate of breakwater.
Water Quality	Data incomplete to compare with State Water Quality Standards.	
	High salinity gradient.	Eventual decrease in gradient depending on fate of breakwater.
	High turbidity, high nutrient concentration.	Eventual decrease in turbidity depending on fate of breakwater.
	High sedimentation.	No effect on sedimentation rate.
	Pollution discharges terminated.	Eventual increase in dissolved oxygen.
	Circulation	Decrease circulation with breakwater. Deterioates - then increase.
Sediment Quality	Sediments contaminated with Arsenic, PCB and Pesticides.	No change

TABLE 3. COMPARISON OF ALTERNATIVE IMPACTS (Cont)

Resource	Plan B, and Base Condition	Plan A
Historic Properties Hilo Breakwater	Hilo Breakwater eligible for inclusion to National Register of Historic Places.	Effect will depend on modification selected.
Discharge of Fill or Dredged Material	Not applicable.	Clean basalt rock fill.

4. AFFECTED ENVIRONMENT.

4.1 ENVIRONMENTAL CONDITIONS.

a. Hilo is the capital and business center of the County of Hawaii. The 1980 population of Hilo was 42,320 (State of Hawaii, 1980), and continues to grow at a slow rate in comparison to the Kona side (western side) of the island. Hilo is considered a mildly depressed area with disproportionately higher unemployment than the State and one of the lowest visitor counts in a State where tourism is a major industry. Hilo's principal industry is sugar production, which is stable but not growing. The principal employers in Hilo are government, services and trades. The city of Hilo is situated along the shoreline of Hilo Bay and is a fully developed urban area. A University of Hawaii campus is located in the city together with the main county hospital, modern shopping centers and a variety of other commercial establishments. Hilo Harbor is the principal port-of-call and handles most of the cargo, agricultural and petroleum shipments in the County.

b. Hilo Bay shoreline is essentially developed park open space as a result of local land use zoning in the tsunami hazard area. Residences are located along Baker's Beach and on Waiakea Peninsula along Banyan Drive. The developed nature of the shoreline and the high urbanized nature of the area precludes significant vegetation and wildlife habitats, except in Waiakea Pond and Wailuku River. The breakwater, Wailoa and Wailuku Rivers, and groundwater seepage into Hilo Bay are the principal factors influencing water quality in the bay. The breakwater traps freshwater discharged into the bay and reduces water circulation and exchange creating a significant salinity gradient in the bay. Sediment, cane and vegetation trash carried into the harbor by the tributaries discourage water contact recreation in the bay. Boating, recreational fishing, canoeing, and surfing are the significant water contact recreational activities in the bay. Commercial fishing in the bay has declined although the principal commercial fishing facility in the region is located at Suisan Harbor at the mouth of the Wailoa River.

4.2 SIGNIFICANT RESOURCES.

a. Recreation occurs all along the bay shoreline. Mooheau and Bayfront beach parks extend along the bay shoreline from the Wailuku River to the Wailoa River. There are both boat berthing and open space recreation in Wailoa River Park. Liliuokalani Gardens and Coconut Islands provide open space along the Waiakea Peninsula. Reed's Bay and Baker's Beach are swimming areas relatively free of trash from the Wailuku and Wailoa Rivers. Radio Bay is used for berthing of recreational craft and the Radio Bay Park provides additional open space within the harbor area. Hilo Breakwater is a frequently used fishing site, despite signs warning fishermen of the hazardous conditions on the breakwater. The breakwater is frequently overtopped during high surf conditions, and waves can sweep fishermen from the breakwater. Recreational fishing is the most significant recreational activity in the bay. Fishermen use every location in the bay as a fishing site, including the harbor facilities. Boating and canoeing are also important recreational activities together with wading. Swimming is not a major recreational activity, possibly due to the highly turbid waters in the bay, and the trash in the water and on the shoreline. Five surf sites in the bay were identified by Kelly, 1981.

b. Natural Hazards.

(1) Volcanic Hazards. Hilo is located in a high risk volcanic area exposed to lava flow threats, earthquakes and subsidence. The risk generally decreases with distance from the northeast rift zone of Mauna Loa volcano. During the past 15 years the island of Hawaii has experienced 11 earthquakes with Richter magnitude ratings of 6 or more. The most recent in 1975 resulted in an estimated $4 million dollars of damage island wide. Most lava flows from Mauna Loa have stopped short of the Hilo suburbs. Public fears of volcanic damages and losses are still significant. At the present time, the Corps of Engineers is seeking Congressional authorization at the request of the State of Hawaii to react to threatening lava flows under emergency conditions.

(2) Riverine Flood and Tsunami Hazards. Hilo is subject to riverine flooding principally due to high intensity rainfall and surface runoff in undefined drainage ways. The flood prone areas are located within the Alenaio Stream floodplain, which is a tributary to the Wailoa River. Hilo is also subject to tsunami flood hazards. The tsunamis of 1946 and 1960 were particularly destructive resulting in the loss of 234 lives and about $52 million in property damage. After the 1960 tsunami, vulnerable waterfront areas were rezoned to open space, such as the Bayfront and Wailoa River Parks, and structural design regulations were imposed in order to reduce tsunami damages.

c. Endangered Species. The endangered humpback whale seasonally migrates through waters outside of Hilo Harbor. The whales begin to appear in November and leave the islands by the end of June. The greatest number of whales in the islands appear during February and March. The National Marine Fisheries Service indicates that no whales have been sighted inside Hilo Harbor. Data indicate that the whales concentrate at Upolu Point in northern Hawaii, and suggest that the Hilo Harbor area is not a calving, nursing and breeding area in the Hawaiian Islands. The endangered hawksbill turtle and the threatened green sea turtles have been observed in Hilo Harbor possibly foraging for food. No nesting grounds exist in the harbor and no seasonal aggregations in the harbor have been reported. The turtles are also reported by the National Marine Fisheries Service to forage along the entire coastline from Hilo to Kalapana.

d. Estuaries. Reed's Bay, Waiakea Pond, Wailoa River and Wailuku River are estuaries within the Hilo Bay and Harbor area. Approximately 1000 mgd of freshwater is discharged into the harbor from the tributaries and springs. The estuaries are important recreational fishing areas within the bay and are planned for open space. Reed's Bay, Wailoa River and Waiakea Pond are planned by the local government for park use, and Wailuku River is planned as a natural wilderness area.

e. Marine Resources. The two important marine areas within the bay are the areas with the greatest coral cover, Blonde Reef (0-16% coral cover) and Coconut Island (0-10% coral cover). Both the live and dead coral mass on Blonde Reef and at Coconut Island provide habitat for a variety of reef fish important to recreational fishing in the bay. Commercial fishing in the bay has declined, but the sale of the catch occurs at Suisan Harbor and fish market at the mouth of the Wailoa River. Fishermen suggest that fish stocks are declining due to over-exploitation, sedimentation and chemical pollution. Although exact factors affecting fish abundance have not been determined, high water turbidity does reduce spear fishing success and sedimentation can bury fish shelter and food resources reducing the amount of nearshore fish habitat.

f. Water Quality.

(1) The data are insufficient to compare existing conditions with new State of Hawaii Water Quality Standards which were revised in September 1979. Based on previous standards, water quality in Hilo Bay was poor due to high nutrient concentrations, high water turbidity, high suspended solids concentration and high chlorophyll-a concentration. However, water quality is significantly improved from the past when sugar mills, the Canec Plant and the City of Hilo discharged their wastewaters directly into the bay.

(2) In general, water inside and outside the breakwater is vertically stratified due to the substantial discharge of ground and riverine water into the ocean. The salinity gradient inside the harbor is greater than that outside due to the reduced mixing behind the breakwater. The depth of the fresh/brackish water layer in the bay reaches 20 feet indicating that mixing is occurring between surface and bottom layers, but not sufficient to reduce the salinity gradient. The depth of fresh/brackish water layer on Blonde Reef reaches 10 feet inside the breakwater. The primary water column mixing forces are wind and occasional ship traffic. Nutrient concentrations and suspended solids and turbidity vary with the volume of surface runoff and groundwater discharge entering. Fecal strep bacteria tend to survive longer in the bay due to the freshwater layer in the bay than other areas in the State. Chlorophyll-a concentration varys with water turbidity, increasing during periods of low riverine flow and decreasing during periods of high flow. Water temperature in the surface layer is warmer than the bottom layer due to solar heating, but is colder near the source of groundwater discharge. During periods of low freshwater discharge, solar heating can warm the bottom layer because the depth of the freshwater layer is reduced.

(3) Sedimentation and Sediment Quality. The sediment in the harbor entrance channel and turning basin consists of silty-clays. The low wave energy environment behind the breakwater allows much of the water-borne sediment to settle out in the harbor and on Blonde Reef where the sediment is smothering and destroying the reef ecosystem. The rate of sedimentation may be slow based upon the frequency of maintenance dredging in Hilo Harbor -- once every ten years. In 1977, about 54,000 cubic yards of material was removed from the harbor during the maintenance cycle and the material was disposed of by ocean dumping at the EPA approved Hilo ocean disposal site. However, about 35,000 tons of silt per year are deposited in the bay from the Wailuku River. The quantity may be less than in the past, because of an 1881 lava flow which covered up erodible soils within the Wailuku River drainage basin, and the termination of the discharge of 20,000 tons of sediment a year from the Wainaku Sugar Mill which closed in 1976. Based upon sediment analysis by the State Department of Health, Hilo Bay sediments are contaminated with arsenic, Polyclorinated Biphenols (PCB) and chlordane. Arsenic trioxide was discharged into Waiakea Pond by the Canec Plant. The PCB's probably originated from the Shipman Power Plant near the Wailoa River. Chlordane probably occurs due to agricultural activities and its use as a termicide in home construction in Hilo.

TABLE 3

Contaminant Concentration in Hilo Harbor Sediments.

Total Arsenic concentration: range from 33-104 parts per million (ppm)

PCB concentration: a mean value of 200 parts per billion (ppb)

Chlordane concentration: range from 2-84 ppb

Source: State of Hawaii 1978

Tests of crab and fish tissue indicate that arsenic and PCB are not bioconcentrating in the tissue. Fish viscera contained chlordane residue in concentrations 3-4 times higher than the flesh, where concentrations ranged from 80-160 ppb.

g. Air Quality. Air quality in Hilo is good, lacking major industrial emissions. The sulfur dioxide concentration in 1980 was less than 5 micograms per cubic meter. Volcanic gases, agricultural fires, sugar mills, both aircraft and automotive engines and the power plant are the only major sources of air pollution in the Hilo area.

h. Noise. Hilo is a quiet urban area with the exception of aircraft landing and taking off from Hilo Airport, the aircraft landing pattern takes aircraft over the bayfront area.

i. Historic Resources. The Hilo Breakwater was determined to be eligible for inclusion to the National Register of Historic Places by the Keeper of the Register in 1980. The Keeper of the Register indicated that the breakwater was significant in the areas of commerce and transportation for the vital role that it played in the development of the port of Hilo, the historic main port of entry for the island of Hawaii, and that the breakwater has retained its essential physical integrity despite alterations to its original design, function and visual appearance. The State Historic Preservation Officer had indicated that the breakwater was associated with events that facilitated railroad and port expansion in Hilo, that reestablished Hilo as the hub of transportation on the island of Hawaii and that contributed to the growth of Hilo. The 2-mile long breakwater is also the longest breakwater in the State and continues to be a visible entity in the bay. The breakwater has stood 1 mile offshore in Hilo Bay for the last 50 years; and has been damaged by past tsunamis. Over the years design changes have been necessary to maintain navigation safety in the bay and to allow continued use of the port by Hawaii's industries, and the appearance of the breakwater has been altered significantly.

5. ENVIRONMENTAL EFFECTS.

5.1 SOCIAL. The improvements will not alter Hilo's population growth or influence its existing economic trend. No humans will be displaced. The harbor will remain in industrial and commercial use, and management will remain with the State of Hawaii.

5.2 RECREATION. Neither of the plans will have a direct impact on existing park areas in Hilo Bay. However, when part or all of the existing breakwater has been removed or allowed to deteriorate, there will be a reduction of available fishing sites. The eventual modification of the existing breakwater may improve surfing in the bay due to increased wave action on Blonde Reef and around Wailuku River and Coconut Island. Such modification may also reduce erosion along Hilo Bayfront Beach by reestablishing the westward littoral transport along the beach.

5.3 NATURAL HAZARDS.

a. Volcanic Hazards. Neither of the plans increase or decrease volcanic hazard risks.

b. Tsunami and Riverine Flood Hazards. Neither of the plans affect riverine flooding along the Alenaio Stream floodplain. Eventual reduction of the breakwater length by 7000 feet may possibly allow a higher tsunami wave to reach the shore, since the breakwater may presently reduce the tsunami wave energy. Model or other engineering studies will be performed to determine the effect of breakwater removal or deterioration on the tsunami hazard.

5.4 ENDANGERED SPECIES.

a. Endangered Humpback Whale. Neither of the plans will affect the migratory route of the humpback whale, or any critical whale calving, nursing or breeding areas in Hawaii.

b. Endangered Hawksbill Turtle and Threatened Green Sea Turtle. This project will probably increase foraging habitat in Hilo Harbor when the breakwater is eventually lowered to sea level. The speed with which this occurs will depend on the fate of the breakwater. Neither of the plans would affect turtle nesting areas or areas of turtle aggregations in Hawaii. The plans would not eliminate foraging areas along the coast outside of Hilo Harbor.

5.5 MIGRATORY WATER BIRDS. Neither of the plans will effect migratory water birds.

5.6 ESTUARIES. Neither of the plans will effect the Wailuku River, Wailoa River, or Reed's Bay estuaries.

5.7 MARINE RESOURCES.

Plan A will eventually benefit the environment. Increased wave energy over Blonde Reef should gradually flush silt from the reef reopening habitat for fishery resources and possibly allowing the recolonization of coral on the reef. If wave energy along the Hilo shoreline is increased, other silt covered areas may also be cleared allowing recolonization to occur. The U.S. Fish and Wildlife Service and the State Aquatic Resources Division feel that removal or gradual deterioration of the breakwater may adversely affect nehu schools, which are occasionally found behind the breakwater.

5.8 WATER QUALITY.

a. Periodic rainstorms cause large amounts of sediments to be discharged from the tributaries entering Hilo Bay, creating a high degree of turbidity. Usually the color of the water returns to normal within a day, but transmissiometer and visual underwater observations indicate that fine sediments remain in suspension longer, obscuring underwater visibility and inducing stress on photosynthetic organisms. The period of stress may last for an extended period due to the poor circulation in Hilo Bay. Neither of the Plans affect the amount of sediment carried into the Harbor, but the changes in current patterns resulting from modifications to the breakwater will alter the sedimentation patterns, and may increase the amount of sediment carried out of the Harbor.

(b) The shallow areas in the Harbor have a good rate of water exchange due to tide and water movement in the top layer induced by the wind, in comparision to the deep areas in the Harbor where tidal movement is the only significant factor affecting water movement and exchange. The new breakwater will reduce water exchange between the commercial harbor and the rest of the bay, and further degrade the water quality in the bay until the old breakwater is changed significantly by deterioration or other means.

(c) In the outer harbor, wave energy over Blonde Reef will increase as the breakwater deteriorates or due to other breakwater modifications, such as breaching or lowering. Wave turbulence will increase the amount of dissolved oxygen in the water over the reef. Water currents will carry the oxygen laden water into the bay, possibly improving dissolved oxygen concentrations in the deeper areas. Wave turbulence will also decrease the salinity gradient over the reef. The less saline top layer presently extends to a depth of 10 feet over the reef. Presently wind, ship traffic and shear forces between the layers are factors influencing mixing in the bay. Wave energy will add another factor influencing mixing and the water pushed into the bay by wave action will be a force influencing the rate of water exchange.

d. Neither of the plans will improve or further degrade sediment quality, but the continued movement of contaminants from inland and upland sources into the bay and the movement of contaminated sediment in the bay into uncontaminated areas maintains existing conditions in the bay sediment quality. If, however, more sediments are carried out of the bay because of improved circulation, the sediments would probably become less contaminated sometime in the future.

5.9 NOISE QUALITY. Neither of the plans will result in a long-term increase in noise. The operation of equipment in the construction of the new breakwater or the removal or breaching of the old breakwater will be a temporary noise source. The duration of construction is a gross measure of the extent of the noise pollution. The only inhabited area which will be affected are the homes along Baker's Beach and the hotels along Banyan Drive.

5.10 HISTORIC RESOURCES. Extensive modification of the breakwater may adversely affect the breakwater as a historic site. While the breakwater will continue to exist, its length will be shorter and its configuration will be altered. The port area will continue to exist and its operational capability improved. The history of the Hilo Area and breakwater is recorded in a historical report prepared by the Bishop Museum for the Corps of Engineers Honolulu District and the remaining portion of the breakwater will continue to serve its historic function.

6. PUBLIC INVOLVEMENT

6.1 PUBLIC INVOLVEMENT PROGRAM. The public involvement program has consisted of meetings and workshops with the public at large, meetings and workshops with members of the Federal, State, and County agencies, and the distribution of various reports and documents resulting from studies conducted under the Hilo Area Comprehensive Study (HACS) to the public and agencies concerned with the progress of all the projects encompassed by the HACS, including water quality improvements to Hilo Bay. In total, 10 public meetings were held including the initial public meeting in 1976, and eight technical studies have been released to the public. Tsunami hazards were the most frequent concern expressed by the public and the agencies. Needs for small craft berths, ramps, and other facilities were also discussed at these meetings, and beach restoration of the Bayfront beach was the most frequently mentioned recreational need.

6.2 REQUIRED COORDINATION. The following coordination must be completed with the following agencies:

a. CZM Consistency. A Hawaii Coastal Zone Management Program evaluation to determine project consistency with the program must be coordinated with the State Department of Planning and Economic Development.

b. Endangered Species Act Consultation. A determination of no effect on the Federal Listed endangered or threatened species was received from the National Marine Fisheries Service and the U.S. Fish and Wildlife Service.

c. US Fish and Wildlife Coordination. The US Fish and Wildlife Service has provided a preliminary opinion of project impact on fish and wildlife resources, and a formal report will be included in the final project report and environmental impact statement.

d. Historical and Cultural Coordination. Plan A requires coordination with the State Historic Preservation Officer (SHPO) and the US Advisory Council on Historic Preservation since the plan involves the eventual modification of the historic Hilo breakwater. A determination of effect was received from the SHPO on 10 August 1981. The SHPO determined the project would have an adverse effect on the breakwater. Coordination is continuing with the SHPO and the Advisory Council.

f. Floodplain Evaluation. Not required since the project is not located in a floodplain.

g. Wetland Evaluation. Not required due to the absence of the resource.

h. National Environmental Policy Act. Following public renew of the draft EIS, the final EIS must be filed with the U.S. Environmental Protection Agency.

i. State and County Approvals. The State of Hawaii, Department of Transportation, is responsible for obtaining all necessary local permits and approvals and satisfying the State NEPA requirements. The Federal EIS and CZM consistency request discuss the construction impacts and compatibility of the action to local policies, but does not address actions to be planned by the State.

6.3 STATEMENT RECIPIENTS. The following agencies and public-at-large are being sent copies of the draft environmental statement and survey report.

Federal Government

US Advisory Council on Historic Preservation
- Washington DC Office
- Western Project Review Office

US Environmental Protection Agency
- Office of Environmental Review
- Region IX
- Pacific Islands Office

Federal Government (contd)

- US Army Corps of Engineers
  - Coastal Engineering Research Center
- US Department of Agriculture
  - Institute of Pacific Islands Forestry
  - Soil Conservation Service
  - Hawaii District Office
- US Department of Energy
- US Department of Commerce
  - Secretary of Environmental Affairs
  - National Marine Fisheries Service
    - * Southwest Region Office
    - Pacific Program Office
  - Office of Coastal Zone Management
  - National Weather Service, Pacific Region
- US Department of the Interior
  - Office of Environmental Review
  - US Geological Survey, Hawaii Volcano Observatory
  - Secretary Field Representative, Pacific Southwest Region
  - US Fish and Wildlife Service
    - Regional Office
    - Pacific Islands Office
    - Endangered Species Coordinator
  - National Park Service
    - Office of Archaeological and Historic Preservation
    - Interagency Archaeological Service
    - Arizona Archaeological Center
    - Pacific Southwest Region Office
    - Hawaii State Office
- * US Department of Housing and Urban Development
- US Department of Health, Education and Welfare
- US Department of Transportation
  - * Federal Highway Administration - no comment
  - 14th Coast Guard District
    - Cape Small, Hilo
  - Federal Maritime Commission

State Government

Governor George R. Ariyoshi
Hawaii Congressional Delegation
Department of Planning and Economic Development - Clearinghouse
Department of Health
* Office of Environmental Quality Control
International Tsunami Information Center
* Department of Land and Natural Resources
* State Historic Preservation Officer
Division of State Parks
Division of Fish and Game
Forestry and Wildlife Division
Land Management Division
Water and Land Development Division
Conservation and Resources Enforcement Division
Hawaii District and Agent
Board of Land and Natural Resources
Marine Affairs Coordinator
Department of Transportation
Highways Division
Harbors Division
Department of Accounting and General Services
Attorney General
State Department of Agriculture
Board of Agriculture
Public Utilities Commission
Hawaii State Library
Hawaii Island Branches
Department of Hawaiian Home Lands
Keaukaha School

County Government

Mayor Herbert T. Matayoshi
Hawaii County Council
Hawaii Legislative Delegation

County Government (cont.)

Department of Parks and Recreation
Department of Planning
Planning Commission
Department of Public Works
Department of Research and Development
Department of Water Supply
County Fire Department
Department of Civil Defense

Organizations

Big Island Resource Conservation and Development Council
Big Island Casting Club
Association of Hawaiian Civic Clubs
Big Island Fish and Game Association
Conservation Council for Hawaii
  Hawaii Island Chapter
Hale Consultants, Inc.
Hawaii Audobon Society
Hawaii Community College Library
Hawaii Electric Light Co.
Hawaii Island Board of Realtors
Hawaii Island Chamber of Commerce
Hawaii Tribune Herald
Hawaiian Civic Club
Hawaii Leeward Planning Conference
Hilo Transportation and Terminal Co., Inc.
Hilo Trolling Club
Hawaiian Paradise Park Corp.
Hilo Sailing Club
Life of the Land
Kalapana Community Association
Hilo Downtown Improvement Association
Kailua Trolling Club
Kawaihae Trolling Club

Organizations (cont.)

Japanese Chamber of Commerce and Industry of Hawaii
Kona Mauka Troller, Inc.
Kona Yacht Club
Mark's Boat Works
North Hilo Community Council
Moku Loa Sierra Club Group
Matson Navigation Co.
Puna Community Council
Suisan Co.
Save Our Surf
University of Hawaii
    Water Resources Research Center
    Library
    Environmental Center
    Hawaii Institute of Marine Biology
    Seagrant/Marine Advisory Program, Kona and Hilo Offices
Young Brothers Inc.
Wester Division Project Review, Lake Plaza South

Individuals

Mr. Alika Cooper
Mr. Dan Pakele
Mr. Dave Soderland
Mr. Edward Bumatay
Mr. Herbert Mann
Ms. Lei Keliipio
Mr. Paul Friesema

6.4 PUBLIC VIEWS AND RESPONSES. (To be completed after review of the draft environmental impact statement.)

BIBLIOGRAPHY

Aotani and Associates. 1977. Preliminary Planning for Small Craft Facilities in East Hawaii.

Belt, Collins and Associates. 1975 for the County of Hawaii. Hilo Community Development Plan.

Brock, Richard E. 1977 for the US Army Corps of Engineers, Honolulu District. A Five Year Study of Marine Fish Colonization in Honokohau Harbor, Kona, Hawaii.

Chiniago, Inc., 1981 for the US Army Corps of Engineers, Honolulu, District. Leleiwi Point and Kalapana, Hawaii: Archaeological Reconnaissance for the US Army Corps of Engineers, Honolulu District.

County of Hawaii. 1971. The General Plan, County of Hawaii.

Hawaii Water Resources Regional Study. 1975. Study Element Report, Surface and Groundwater Resources.

___________. 1975. Study Element Report, Water Supply.

Harvey, G. W., et al. 1971 for the US Army Corps of Engineers, Honolulu District. Preliminary Results: Ecological Survey of Honokohau Harbor, August and September 1971.

Herman, Louis M. Hawaii's Giant Visitors, in the Star Bulletin 23 March 1981.

Hiroshi Kasamoto Inc., and P. Yoshimura Inc. 1979 for the County of Hawaii. Draft Puna Community Development Plan. (Not accepted by the County of Hawaii).

Kelly, M., Bishop Museum. 1981. Hilo Bay, A Chronological History.

M and E Pacific. 1980a for the US Army Corps of Engineers. Hilo Area Comprehensive Study, Geological, Biological and Water Quality Investigations of Hilo Bay.

___________. 1980b for the County of Hawaii. Environmental Impact Statement for the Hilo Wastewater Management Plan of the Hilo District, South Hilo, Hawaii.

Mullineaux, Donald R. and Donald W. Peterson. 1974. Volcanic Hazards on the Island of Hawaii. US Geological Survey Open File Report 74-239.

Neighbor Island Consultants, Inc. 1973 for the US Army Corps of Engineers, Honolulu District. Baseline Environmental Investigation of Hilo Harbor.

Oceanic Foundation. 1975 for the US Army Corps of Engineers, Honolulu District. A Three-year Environmental Study of Honokohau Harbor, Hawaii.

Resource Planning, Inc. 1977 for the US Army Corps of Engineers, Honolulu District. Fisheries Assessment for First Spring Season Environmental Studies, Hilo Bay, Hawaii, June 1977.

Raymond, L. P. 1973 for the US Army Corps of Engineers, Honolulu District. An Environmental Survey of Honokohau Harbor, 1972.

Rice, Dale W. 1978. The Humpback Whale in the North Pacific: Distribution, Exploitation and Numbers, in a US Department of Commerce Report on a Workshop on Problems Related to Humpback Whales (Megaptera novaeangliae) in Hawaii.

Rice, E. W. and Allen A. Wolman. 1978. Humpback Whale Census in Hawaiian Waters-February 1977, Preliminary Report on an ongoing Study, in a US Department of Commerce Report on a Workshop on Problems Related to Humpback Whales (Megaptera novaeangliae) in Hawaii.

State of Hawaii, Department of Agriculture. 1977. Maps of Agricultural Lands of Importance in the State of Hawaii.

State of Hawaii. Department of Planning and Economic Development. 1980. The State of Hawaii Data Book, 1980, Statistical Abstract.

State of Hawaii, Department of Land and Natural Resources. 1980. State Recreation Plan, Technical Reference Document.

Shallenberger, Edward W. 1977. Humpback Whales in Hawaii, Population and Distribution, in Oceans 1977.

Sunn, Low, Tom and Hara, Inc. (now M&E Pacific). 1977. Hilo Harbor, First Spring Season Environmental Studies.

Stearns, H. T. and G. A. Macdonald. 1946. Geology and Groundwater Resources of the Island of Hawaii. Bulletin 9, Hawaii Division of Hydrography, Territory of Hawaii.

Takata, Howard. 1981 personal communication on turtle nesting at Harry K. Brown Beach Park. Hilo Seagrant Office.

US Army Corps of Engineers, Honolulu District. 1978. Final Detailed Project Report and Environmental Impact Statement, Pohoiki Bay Navigation Improvements, Pohoiki Bay Hawaii.

__________. 1976. Plan of Study, Hilo Area Comprehensive Study.

US Department of Housing and Urban Development. 1979. Flood Insurance Rate Map.

US Fish and Wildlife Service. 1977. The Biological Resources of the Hilo Study Area, Hawaii, An Overview.

US Geological Survey. 1975. Natural Hazards on the Island of Hawaii. Geological Survey Report USGS: INF-75-18.

US National Park Service. 1980. Glacier Bay National Monument, Protection of Humpback Whales, Final Rule, Federal Register 45(96):32228 (15 May 1980.
US Soil Conservation Service. 1973. Soil Survey of Island of Hawaii, State of Hawaii.

Wolman, Allen A. and Charles M. Jurasz. Undated. Humpback Whales in Hawaii, Vessel Census, 1976.

LIST OF PREPARERS

The following people were primarily responsible for preparing this Environmental Impact Statement.

Dr. James E. Maragos	Marine Ecology	BS, Zoology; PhD, Oceanography; 2 yrs postdoctoral research; 8 yrs environmental consultant; 8 yrs EIS studies, Corps of Engineers.	Review overall impact assessment. (NEPA Coordinator)
Mr. William B. Lennan	Biology	BA, Zoology; 2 yrs postgraduate studies, University of Hawaii; 3 yrs fishery biologist, USFWS 1 yr environmental biologist Corps of Engineers.	Overall impact assessment.
Mr. David G. Sox	History and Culture	BA, MA Geography; 6 yrs research; 7 yrs EIS studies; Corps of Engineers.	Cultural and historical impact assessment.
Mr. David W. Sox	Archaeology	BA, Anthropology; 2 yrs postgraduate studies; w/diploma in cultural resources management, EWC; 1 yr EIS studies, Corps of Engineers.	Archaeological/historic sites reconnaissance and impact assessment.
Mr. John I. Ford	Limnology	BS MS Zoology; 4 yrs EIS studies, Corps of Engineers; 1 yr, fishery biologist, USFWS.	Fish and Wildlife assessment.

APPENDIX A

404(b) (1) EVALUATION

A. DISCHARGE OF DREDGED OR FILL MATERIAL, BREAKWATER IMPROVEMENTS, SECTION 404(b)(1), FACTUAL DETERMINATION.

1. Special Aquatic Areas.

Sanctuaries and Refuges: None.

Wetlands: None.

Mudflat: None.

Coral Reefs: Portions of the discharge will occur on Blonde Reef, the major reef in Hilo Bay. Coral cover on the reef varies from 0-16% reflecting a decline in coral growth probably caused by the breakwater reducing wave energy and flushing on the reef, and increasing freshwater and sedimentation stress. Surveys suggest that the breakwater reduces water column mixing in the bay resulting in the development of a two-layered water body, where freshwater reduces water salinity to a depth of 10-20 feet in the bay. Reduced wave energy permits silt, carried into the bay by tributaries, to settle out on the reef, smothering benthic organisms, particularly coral. By contrast, portions of the reef outside of the breakwater have coral cover ranging from 40-70%. Effect: The discharge of fill material in Plan A results in some loss of reef habitat, however, more reef will be revitalized when the breakwater is eventually removed. If the removal occurs due to deterioration, this revitalization could take a very long time.

Base Condition	Plan A	Plan B
220 acres available inside the breakwater	6.2 acres covered. 2 acres rocky intertidal habitat created.	No effect

Riffle and Pool Complex: None.

2. Human Use Characterization.

Municipal Water Supply: Not applicable.

Recreational and Commercial Fisheries: Hilo Bay supports a large recreational shoreline fishery, and fishing sites are located all along the bay shoreline. Fishing within the discharge area occurs from Hilo breakwater and from the Baker's Beach shoreline. Recreational boaters possibly troll in the discharge areas. Common reef and nearshore coastal (neritic) fish are caught in the bay (see Attachment 1 for fish species list). The productivity of the fishery has not been measured, however, the fishery resource supports an estimated 2,100 local recreational shoreline fishermen, based on a 1972 survey (Hoffman and Yamauchi in Cheney, 1977). The State Division of Fish and Game indicated that 456 two-year permits for night fishing in the bay were issued between May 1975 and May 1976. Commercial fishing in Hilo Bay is no longer a significant industry. Effect: While the discharges will eliminate water area in the bay, the breakwater and fill structure will also provide new recreational fishing sites in the bay. The effect of the discharge of the rock used in constructing the breakwater will probably provide fish and intertidal habitat partially offsetting loss of fish habitat. Plan A is expected to eventually improve water quality on Blonde Reef, permitting coral to return, thus creating improved fish habitat at some time in the future.

Water-Related Recreation: Surfing, wading, swimming, canoeing and boating are significant recreational activities in Hilo Bay. Blonde Reef is used by boaters and the Baker's Beach area provides open space, and wading and swimming opportunities. One surfing site in the bay is located at the tip of the breakwater. Effect:

Base Condition	Plan A	Plan B
Boating	Breakwater removes 6.8 acres of open water from boating use, and creates new navigation feature in the bay.	No effect
Wading, swimming and open space at Baker's Beach.	No effect	No effect
Surfing at breakwater tip.	Effect Unknown	No effect

Aesthetics: Hilo Bay's vista is dominated by the breakwater. Effect: The discharge will create new visual elements in Hilo Bay.

Plan A - Adds one new breakwater in the bay.

Plan B - No effect.

National Monuments: None.

National Seashores: None.

National Wilderness Areas: None.

Research Sites: None.

National Historic Sites: Hilo Breakwater is eligible for inclusion on the National Register of Historic Places, based on its role in the development of Hilo port. The breakwater is also associated with events that facilitated the expansion of the railroad and port facilities in the Hilo area, the reestablishment of Hilo as the hub of transportation on the island of Hawaii, and the growth of Hilo. The breakwater is also the longest in the State of Hawaii, and has essentially maintained its physical integrity despite alterations to its original design, function and visual appearance. Effect:

Base Condition	Plan A	Plan B
Historial significance.	No effect	No effect
Visual & physical appearance.	Eventually shortened by 7,000 feet.	No effect 7,000 feet.

3. Physical Substrate Determination.

Size Gradation and Coarseness: The Blonde Reef discharge site substrate consists of mud overlying coralline rubble and pavement. Effect: The discharge is associated with the construction of a structure which will cover the substrate and raise the bottom elevations from below mean lower low water (MLLW) to about +15 feet above MLLW.

Compaction: Not applicable. The discharge involves the construction of a breakwater and the fill area is to be protected and confined by a rock revetment.

Bottom Elevation/Contour: See table below:

Base Condition	Plan A	Plan B
Water depths at the discharge site.	-11 to -15' MLLW.	-11 to -15' MLLW.
Condition after the discharge. Breakwater crest elevation.	+15' MLLW.	No change.

Material Movement: Baker's Beach and Bayfront Beach are presently eroding. Effect: Shortening the existing breakwater associated with the discharge may reduce the erosion along the Bayfront Beach. If the existing breakwater crest elevation is lowered or the breakwater is breached, wave energy should increase and possibly restore the westward current component to counteract the eastward erosion on Bayfront Beach.

Deposition: Not applicable.

4. Water Quality, Circulation, Fluctuation and Salinity Determination.

Current Velocity, Direction and Pattern: Presently a predominant surface outflow occurs in the harbor along the breakwater due to the discharge of groundwater and riverine water into the bay. Drogue studies indicate that current velocities vary from 0.03 to 0.19 knots. The ocean water lies beneath the surface, freshwater layer, and its movement is tidal dependent with no set current direction. Effect:

Plan A - If the existing breakwater crest elevation is lowered or the breakwater is breached, increased wave energy on the reef and in the bay may tend to reduce the salinity gradient. The predominant outflow will continue in the inner harbor, but mixing may reduce the current velocity in the outer harbor. Increased wave energy over the reef may create a shoreward current component flushing silt from the reef and possibly restoring surfing conditions in the bay. The increased wave energy may also impart a westward current component along Bayfront Beach that will counteract the eastward current which appears to be responsible for the erosion along the beach.

Construction of the breakwater will tend to isolate the inner harbor from the outer harbor. The breakwater will tend to reduce mixing in the inner harbor, especially if the existing breakwater is not removed for a long time. This reduced mixing may further degrade water quality in the inner harbor.

Downstream Flow: Not applicable.

Normal Water Fluctuations: No estuarine tidal lags are evident in Hilo Bay and the discharges are not expected to interfere with normal tidal fluctuations.

Salinity Gradient/Stratification: A salinity gradient is measurable in Hilo Harbor to a depth of 20 feet at the mouth of the harbor and 10 feet over Blonde Reef. The gradient is related to the amount of groundwater and riverine water discharged into the bay and the percent of freshwater in the surface layer can vary between 25% in the dry season to 75% following a storm event. Salinity measurements in the bay vary from 32-34 parts per thousand in the bottom layer and 11-30 parts per thousand in the surface layer. The formation of the salinity gradient is partially attributable to the breakwater which reduces wave energy as a water-column mixing force in the bay. Mixing is dependent upon wind and tidal forces, and ship traffic in the bay. Effect:

Plan A - The construction of the inner breakwater may increase the salinity gradient and the depth of freshwater influence in the inner harbor. Eventually when the outer breakwater is removed or deteriated to the point that significantly more energy enters the bay, the gradient in the outer area will be reduced.

Potability: Not applicable.

Water Physical Characteristics: Water chemical and physical characteristics in Hilo Bay are dependent upon riverine and groundwater discharges into the bay. Wastewater discharges into the bay were removed. Effect: See Table A-1.

TABLE A-1. DISCHARGE EFFECTS ON WATER CHARACTERISTICS

Base Conditions (Mean Values)	Surface	Bottom	Plan A	Plan B
pH	7.6-8.32	8.04-8.36	Possible very slight decrease in pH when mixing and disolved oxygen improve.	No effect
Temp (°C)	19.7-24.9	23.4-25.2	Possible increase in temperature in inner harbor. No effect in outer harbor until the breakwater deteriorates or is removed.	No effect
Dissolved oxygen (mg/l)	7.59-9.71	4.64-8.00	Probable increase when existing breakwater is removed or deteriorates.	No effect
Total nitrogen (ug/l)	172-403	28.4-90.4	Effect is unknown, but should not be significant.	No effect
Total phosphorus (ug/l)	13.9-53.5	17.8-60.2	"	No effect

Source: M&E Pacific, 1980.

Pathogens/Biological Content: Fecal coliform mean concentrations (number per 100 ml) ranged from 10 to 239 and fecal strep mean concentrations ranged from 62 to 1480. The source of the fecal bacteria was the riverine and storm drainage discharges into Hilo Bay. Effect: No effect expected.

Eutrophication: Not applicable.

5. Suspended Particulate and Turbidity Determination.

Turbidity: The waters in Hilo Bay are highly turbid due to the discharge of suspended material from Wailoa River and other drainage ways into the bay. Turbidity usually increases with the volume of water discharged into the bay. Ship traffic and periodic maintenance dredging (once every 10 years) also contribute to normal turbidity levels in the bay. During the dry season, turbidity is considerably lower than the wet season. High chlorophyll-a and zooplankton concentrations are principal turbidity causing material during the dry season compared with inorganic sediment during the wet season.

	Storm	Wet Season	Dry Season
Turbidity (NTU, mean values)			
Surface	7.82-22.3	2.92-7.52	0.56-1.67
Bottom	4.9-7.65	3.65-9.15	0.69-2.20
Total Suspended Molds (mg/l, mean values)			
Surface	9.30-75.4	6.43-17.3	no data available
Bottom	16.1-44.5	7.40-28.6	

Source: M&E Pacific, 1980.

Effect: The discharge of rock to construct the breakwater in Plan A, is not expected to result in a significant increase in turbidity.

6. Contaminant Determination.

Initial Evaluation:	Plan 1&2	Plan 3
a. The material proposed for discharge:	Basalt rock.	Basalt rock.
b. Source site:	Existing break-water.	Quarry.

Initial Evaluation (Cont):	Plan A	Plan B (No Action)
c. Contaminants can flow into extraction site:	No.	N/A
d. The material proposed for discharge was previously tested.	No.	N/A
e. Can pesticides enter the extraction site.	No.	N/A
f. Spills or disposal of contaminants have been documented in the past.	No.	N/A
g. Natural deposits of minerals or other substances harmful to man are present at the extraction site.	No.	N/A

Findings:

a. The material proposed for discharge in Plan A is not contaminated consisting of basalt stone.

b. The material classification for the basalt stone is Category 5, Discharge without potential for environmental contamination.

c. List of Contaminants to be Further Evaluated: Not applicable. The discharge of Category 5 material does not require testing.

Zone of Mixing: Not applicable. The fill material will be used for construction purposes and will be confined to the fill site by a rock revetment.

7. Aquatic Ecosystem and Organisms Determination.

Fishery resources which support a recreational shoreline fishery are identified in Attachment 1. Corals are major reef organisms, but do not dominate Blonde Reef. Coralline algae presently dominates the reef cementing coralline rubble and dead coral forming the reef foundation.

Rare/Threatened and Endangered Species: The threatened green sea turtle and the endangered hawksbill turtle have been seen near the breakwater and may enter the harbor while foraging for food. No nesting areas are found within the harbor or along the breakwater.

Aquatic Ecosystem Dependency: Fishery resource dependency on Blonde Reef is unknown, however, fish surveys indicate that the most fish species and the greatest number of fish were found on Blonde Reef in comparison to other areas in Hilo Bay. Effect:

Base Condition	Plan A	Plan B
Blonde Reef discharge site:		
52-133 fish counted, 18-21 species represented.	6.8 acres covered, 2 acres rocky habitat formed. Eventual improvement of water quality on inner part of Blonde Reef should increase fishery resource.	No effect
Threatened and endangered turtles.	Possible effect by eventually increasing foraging area.	No effect

The effect of eventual reef revitalization on fishery opportunities and success is unknown, but should result in an increased fish abundance in the bay. Plan A results in improvement of reef habitat in comparison to plan B and could increase recreational fishing success in the bay.

Determination: The discharge of armor units into the harbor under Plan A does not significantly degrade water quality or human uses of the water. The basalt rock is not expected to contain contaminants or cause prolonged water turbidity problems which will significantly degrade the aquatic ecosystem even though a loss of reef area is anticipated.

Material Proposed for Discharge:

	Plan A	Plan B
Basalt rock	117,100 C.Y.	None
Dredged coralline fill	None	None
Dolos armor units	5,500	None

ATTACHMENT 1

CHECK LIST OF FISH AND SHELLFISH TAKEN

BY FISHERMEN WITHIN THE HILO BAY SURVEY AREA

LOCAL/COMMON NAME	SCIENTIFIC NAME	LOCATION BY REGION
Aholehole	Kuhlia sandvicensis	5,6,7,9,11,12,14,16,17
Aku	Katsuwonus pelamis	3
Akule (Aji)/Hahalalu	Trachurops crumenophthalmus	1,6,9,11,14
Amaama (mullet)	Mugil cephalus	5,6,7,8,9,13,15
Awa (milkfish)	Chanos chanos	1,7
Aweoweo	Priacanthidae	16
Ehu (red snapper)	Etelis marshi	4
Hihimanu (ray)	Dasyatidae	11,14
Hinalea (wrasse)	Labridae	9,16
Humuhumu	Balistidae	16,17
Kaku (barracuda)	Sphyraena barracuda	1
Kawakawa	Euthynnus yaito	14
Kumu	Parupeneus porphyreus	1,4,11,14,15,16
Kupipi	Abudefduf sordidus	9,11,16,17
Lae	Scomberoides sancti-petri	9
Maiko	Acanthurus nigroris	16,17
Manini	Acanthurus sandvicensis	11,14,16,17
Mano (tiger shark)	Galeocerdo cuvieri	1
Mano kihikihi (hammerhead shark)	Sphyrna lewini	1,2,11,14,16,17
Maomao	Abudefduf abdominalis	15,17
Menpachi	Myripristis spp.	16
Moano	Parupeneus multifasciatus	1,14,16,17
Moi/moi-lii	Polydactylus sexfilis	3,4,5,6,7,14

ATTACHMENT 1 (Cont)

LOCAL/COMMON NAME	SCIENTIFIC NAME	LOCATION BY REGION
Nehu	Stolephorus purpureus	1,2,11,13,14
Nenue	Kyphosus cinerascens	14
Oio	Albula vulpes	1,5,6,9
Omaka	Caranx mate	1
Oopuhue (balloon fish)	Arothron hispidus	4
Opakapaka	Pristipomoides microlepis	4
Opelu	Decapterus pinnulatus	9
Pakii (flatfish)	Bothus spp.	15
Palani	Acanthurus dussumieri	9,12,13,16,17
Piha	Spratelloides delicatulus	16
Pualu	Acanthurus xanthopterus	1
Puhi (moray eel)	Muraenidae	14
Puhi (tohe--conger eel)	Conger marginatus	14
Taape	Lutjanus kasmira	1,2
Toau	Lutjanus vaigiensis	11
Ulua/Papio	Carangidae	1,3,4,5,6,7,9,11,14,15, 16,17
Upapalu (cardinal fish)	Apogon snyderi	15
Weke/Oama	Mulloidichthys samoensis	1,11,12,13,15
Tilapia	Tilapia spp.	10
Oopu (goby)	Gobidae	5
Crab - Kuanono	Portunus sanguinolentus	3,4,6,7,15
Crab - Samoan	Scylla serrata	3,4
Opae (glass shrimp)	Palaemon debilis	7,8,10,15
Ula	Panulirus spp.	3,4,16,17
Tako (octopus)	Octopoda	4,16,17
Opihi	Cellana spp.	4,16,17

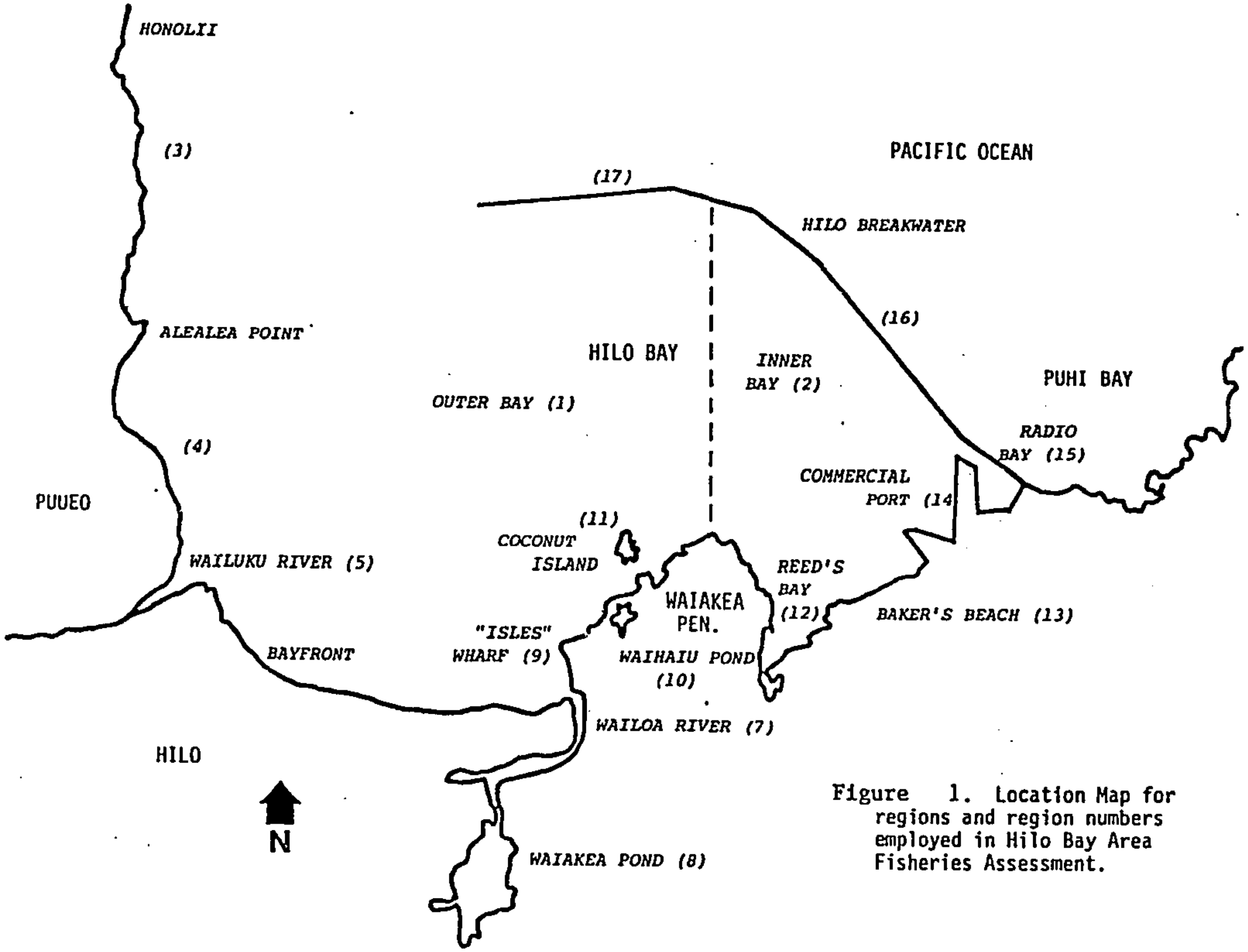


Figure 1. Location Map for regions and region numbers employed in Hilo Bay Area Fisheries Assessment.

From Sunn, Low, Tom & Hara, Inc. 1977

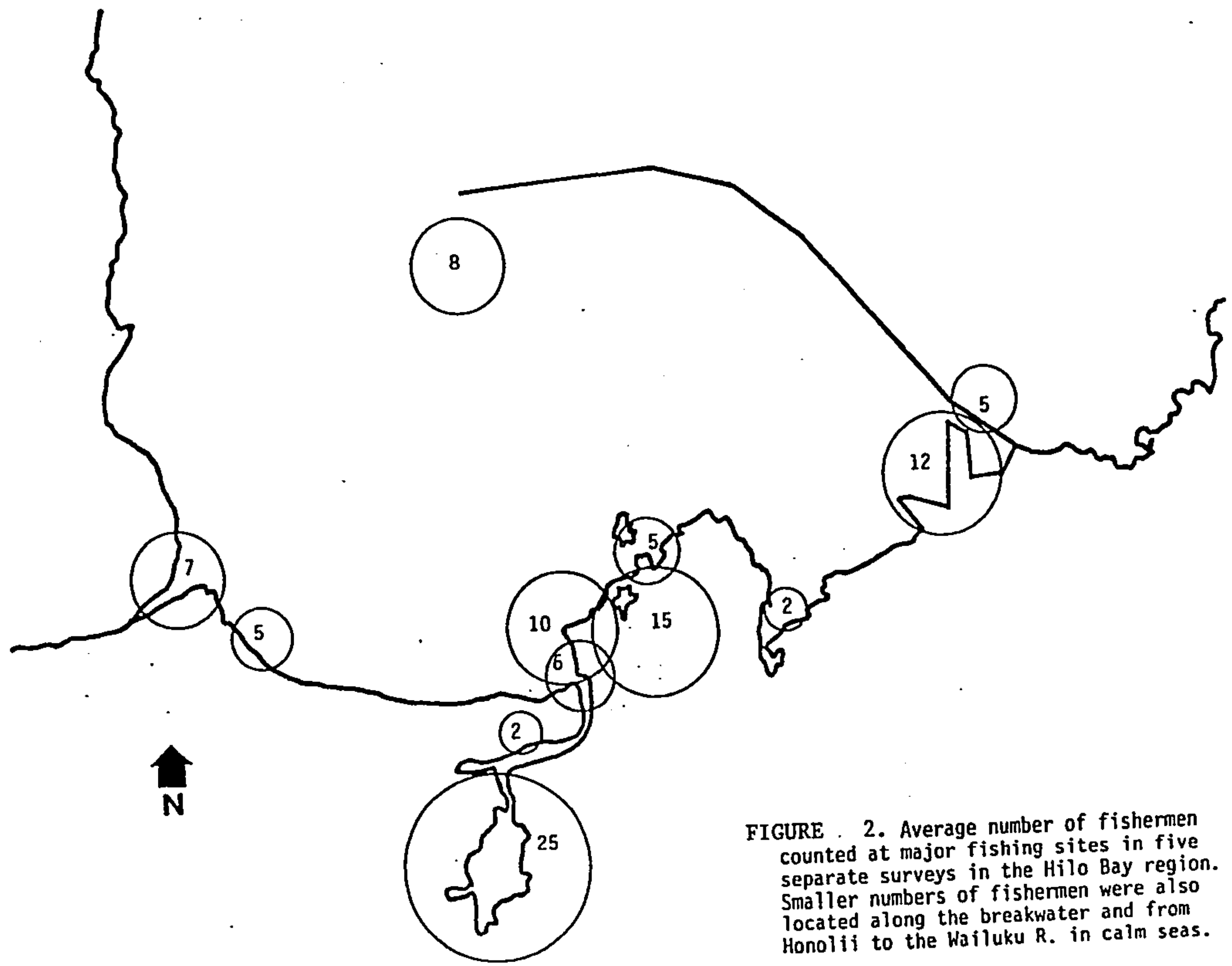


FIGURE . 2. Average number of fishermen counted at major fishing sites in five separate surveys in the Hilo Bay region. Smaller numbers of fishermen were also located along the breakwater and from Honolii to the Wailuku R. in calm seas.

From Sunn, Low, Tom & Hara, Inc. 1977

APPENDIX B

RECREATION AND NATURAL RESOURCES

1. Recreational Resources.

a. National Scenic and Wild Rivers. None present. Local land use planning documents propose the development of Wailuku River as a natural wilderness area and the development of Wailoa River and Waiakea Pond as park, open space.

b. National Trails. None present.

c. Natural Landmarks. None present.

d. National Shoreline Parks or Beaches. None present. Several State and County parks are present along the shoreline. While public access and use of the Hilo Breakwater is discouraged due to hazardous conditions, fishermen use the breakwater as a fishing site.

TABLE B-1. RECREATIONAL RESOURCES

Recreation Site	Acres	Ownership	Park Use
Wailuku River Mouth	-		Surfing
Mooheau Park	18.9		Beach (eroding)
Bayfront Park	6.8		Beach (eroding), canoeing, fishing
Wailoa River Park	146.0	State	General, boating, shoaling, river mouth
Liliuokalani Gardens and adjacent areas	20.5		General
Coconut Island	3.1		General, surfing
Banyan Drive Shoreline	-		Scenic
Reed's Bay	15.5		Beach (man-made) swimming
Baker's Beach		State	Beach (man-made)
Radio Bay		State	Boating
Radio Bay Park		State	General
Hilo Breakwater		Federal	Fishing

e. Water Contract Recreation. Principal water contact recreation activities in Hilo Bay include shoreline fishing, boating, wading and canoeing. Swimming is seldom observed possibly due to the highly turbid nearshore waters and concentrated mats of vegetative debris carried into the bay from the tributary systems. Six surfing sites were identified in Hilo Bay in the "Hilo Bay - a Chronological Study" in 1981. According to the Hawaii Chamber of Commerce, 1973, surfing demands have grown sufficiently to warrant investigations for increasing the number of surfing sites on the island. Fishing and boating are judged the most significant recreational activities. Canoeing is centered on use of the Bayfront beach and Wailoa River. Swimming is most prevalent in Reed's Bay.

(1) Fishing. Recreation fishing areas and resources in Hilo Bay are limited, popular, and need to be protected. Leisure time, recreational fishing is more important in Hilo Bay than commercial fishing as a source of seafood for local residents. Commercial fishing interests are principally interested in the offshore fishing grounds. The number of recreational fishermen in the Hilo Bay area is about 2,100 persons; 60% are shore fishermen, 5% are net fishermen, and the remainder utilize other fishing methods (Cheney, 1977). Favorite fishing sites, list of recreational fish species and general locations where the fish are caught are provided in Cheney, 1977. Fishermen believe that too many fishermen and poor enforcement of fishing regulations are partially responsible for over-exploitation. Fishermen are also competing for water use with canoe paddlers, surfers and boaters. Increasing the number of fishing sites and enforcing existing fishing regulations were believed to be beneficial to recreational fishing in Hilo Bay.

(2) Surfing. Five surfing sites are located in Hilo Bay (Kelly, 1981). One is located at Coconut Island, 2 at the Wailuku River mouth, one at Wainaku, and one at the tip of the breakwater. Kelly indicated that more surfing sites existed in the bay in the 1800's prior to construction of the breakwater.

(3) Beach Parks. The principal beach parks in Hilo Bay are Baker's Beach, Reed's Bay, Hilo Black Sand Beach, and Liliuokalani Gardens. Both Hilo Black Sand Beach and Baker's Beach are man-made. Also, portions of Reed's Bay

were created from material dredged from Hilo Harbor turning basin during the period from 1925-1930. Hilo Black Sand Beach was formed by the natural accretion of eroded basalt material from the 1881 lava flow in the Wailuku River drainage basin. Black sand was mined from the beach in the 1900's. Both beaches are eroding. The creation of Baker's Beach appeared to have altered the dynamic equilibrium of the shoreline area and erosion is believed to be a natural process which reestablishes equilibrium. Erosion at Hilo Black Sand Beach appears to be related to the Hilo Breakwater (Reference M & E Pacific, 1980). The breakwater protects a portion of the beach which has remained stable. However, the exposed portion has eroded and beach sand is transported in an easterly direction. The breakwater appears to have eliminated the westerly component of the littoral transport.

(4) Boating. Wailoa River provides berthing for recreational and fishing craft. A State launch ramp is located in the river. Radio Bay and Reed's Bay are also used for berthing principally for sail craft and vessels with high superstructures which prevent use of the Wailoa River area. Boats using the Wailoa river must have an over-the-water height of less than 8 feet to pass under the Kamehameha Highway bridge. The existing facilities provide berthing for only 106 vessels. Only 4 transient berths are available.

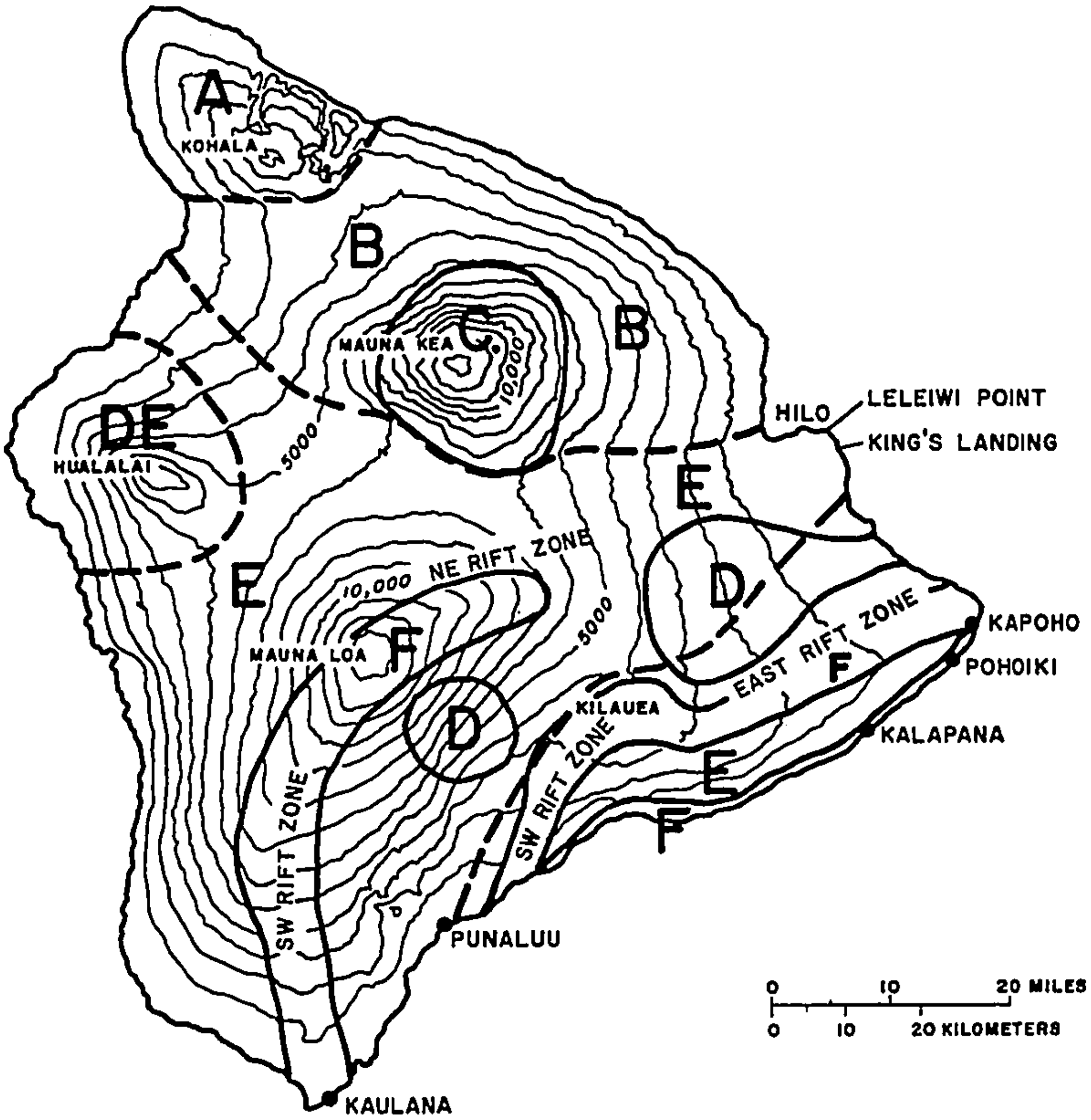
2. Natural Resources.

a. Land Resources. The Hilo Bay shoreline is classified as Keaukaha Extremely Rocky Muck with 6-20% slope. The bay shoreline specifically consists of rocky headlands at Wailuku River, rock revetment and black sand along the Mooheau Beach Park, black sand at the Bayfront Beach park, rock headlands around Waiakea Peninsula, dredged coral fill at Baker's Beach and Reed's Bay and the developed port area. The harbor bottom consists of silty clays carried into the bay from upland areas by the Wailuku and Wailoa Rivers. Blonde Reef is principally a coralline reef area.

b. Prime and Unique Agricultural Lands. None present.

c. Natural Hazards.

(1) Volcanic Hazards.



THE FIVE VOLCANOES THAT FORM THE ISLAND OF HAWAII: KOHALA, MAUNA KEA, HUALALAI, MAUNA LOA AND KILAUEA. CONTOUR INTERVAL 1,000 FEET. DASH LINES SEPARATE NAMED VOLCANOES. (USGS, 1974)

HAZARD DESIGNATION	EXPLANATION
F	AREA OF HIGHEST RISK WITH HISTORIC AND RECENT PREHISTORIC RECORD OF ACTIVE VOLCANISM, FAULTING AND SUBSIDENCE.
E	AREA SUSCEPTIBLE TO BURIAL BY LAVA FLOWS ORIGINATING FROM AREA F. DEGREE OF RISK GENERALLY DECREASES WITH DISTANCE FROM SUMMITS AND MAJOR RIFT ZONES.
DE	HUALALAI VOLCANO ONLY. LAVA BURIAL MORE FREQUENT THAN AREA D, BUT LESS THAN AREA F.
D	MODERATE RISK. NO HISTORIC OR RECENT PREHISTORIC LAVA FLOWS.
C	MAUNA KEA VOLCANO SUMMIT. SMALL RISK. ERUPTION FREQUENCY LOW, LAST ERUPTION 3000 - 5000 YEARS AGO.
B	NO ERUPTIONS DURING LAST 10,000 YEARS.
A	NO VOLCANIC ACTIVITY IN LAST 60,000 YEARS.

SOURCE: USGS, 1975

TABLE B-2 RECORDED OR ESTIMATED NUMBER OF VOLCANIC ERUPTIONS ON THE ISLAND OF HAWAII DURING HISTORIC TIMES (1800-Present)

The summit and major rift zones of Mauna Loa and Kilauea volcanoes on the island of Hawaii have been very active during historic times, and volcanic activity is expected to continue through the foreseeable future.

Volcano	Total Eruptions	Eruptions Outside the Caldera
Mauna Loa	30-40	About 15
Kilauea	40-50	About 25
Mauna Kea	0	-
Hualalai	2	-
Kohala	0	-

Adapted from US Geological Survey, 1974.

TABLE B-3. NUMBER OF ERUPTIONS ORIGINATING WITHIN HAZARD AREAS AND NUMBER OF TIMES LAVA FLOW COVERED LAND WITHIN HAZARD AREAS DURING HISTORIC TIMES (SINCE 1800) ON THE ISLAND OF HAWAII

Hazard Area	# of Eruptions	# of Lava Flows	% Land Covered by Lava
A	0	0	0
B	0	0	0
C	0	0	0
D	0	0	0
DE	1	2	6
E	1	35	15
F	80	More than 80	50

Source: US Geological Survey, 1974.

Hilo is located in a high risk volcanic area (designated risk area E in U.S. Geological Survey, 1974; see Figure B-1). While the greatest danger to Hilo from volcanic activity is associated with eruptions within the northeast rift zone of Mauna Loa, the risk of potential damages and losses from lava flow and other hazards (ejecta, gases, subsidence and surface rupture) generally decreases down the volcanic slopes toward Hilo. Most lava flows from Mauna Loa have stopped short of the Hilo suburbs. Subsidence and surface rupture risks are considered low in Hilo, although earthquake property damage has occurred. An earthquake in 1975 caused about $4 million in property damage throughout the island. Since major structural damage risks are high, earthquake resistant structural design regulations are enforced.

(2) Tsunami and Riverine Flood Hazards

Hilo Bay is susceptible to tsunami and riverine flooding. Forty destructive tsunamis have reached Hilo since 1819, seven of which inflicted loss of life and property. The tsunamis of 1946 and 1960, resulted in the combined loss of 234 lives and damages in excess $52 million. Actions taken to lessen the impact of tsunamis included rezoning of vulnerable waterfront areas to open space and the adoptions of structural design codes to reduce future losses and damages. The highest tsunami runup elevation recorded was 35 feet in 1960. Riverine flood hazards are related to high intensity rainfall, overland sheetflow and undefined drainageways, the last of which is the consequence of the geological youthfulness of the region. The Alenaio Stream flood plain is the principal flood hazard area in Hilo.

d. Vegetation. No significant vegetation communities or species are found around the Hilo Bay shoreline, although the Wailuku River is planned as a natural wilderness area by local planners.

e. Wildlife.

(1) Endangered Species. The endangered Hawaiian coot was observed nesting in Mohouli Pond in Waiakea Pond by Shallenberger, 1977. The endangered hawksbill turtle and the threatened green sea turtle forage along the coastal areas and have been observed near the breakwater. The National Marine Fisheries Service (1981) indicated that Hilo Harbor is not a habitat on which the turtles depend for their continued existence, but that they may enter the harbor while foraging for food.

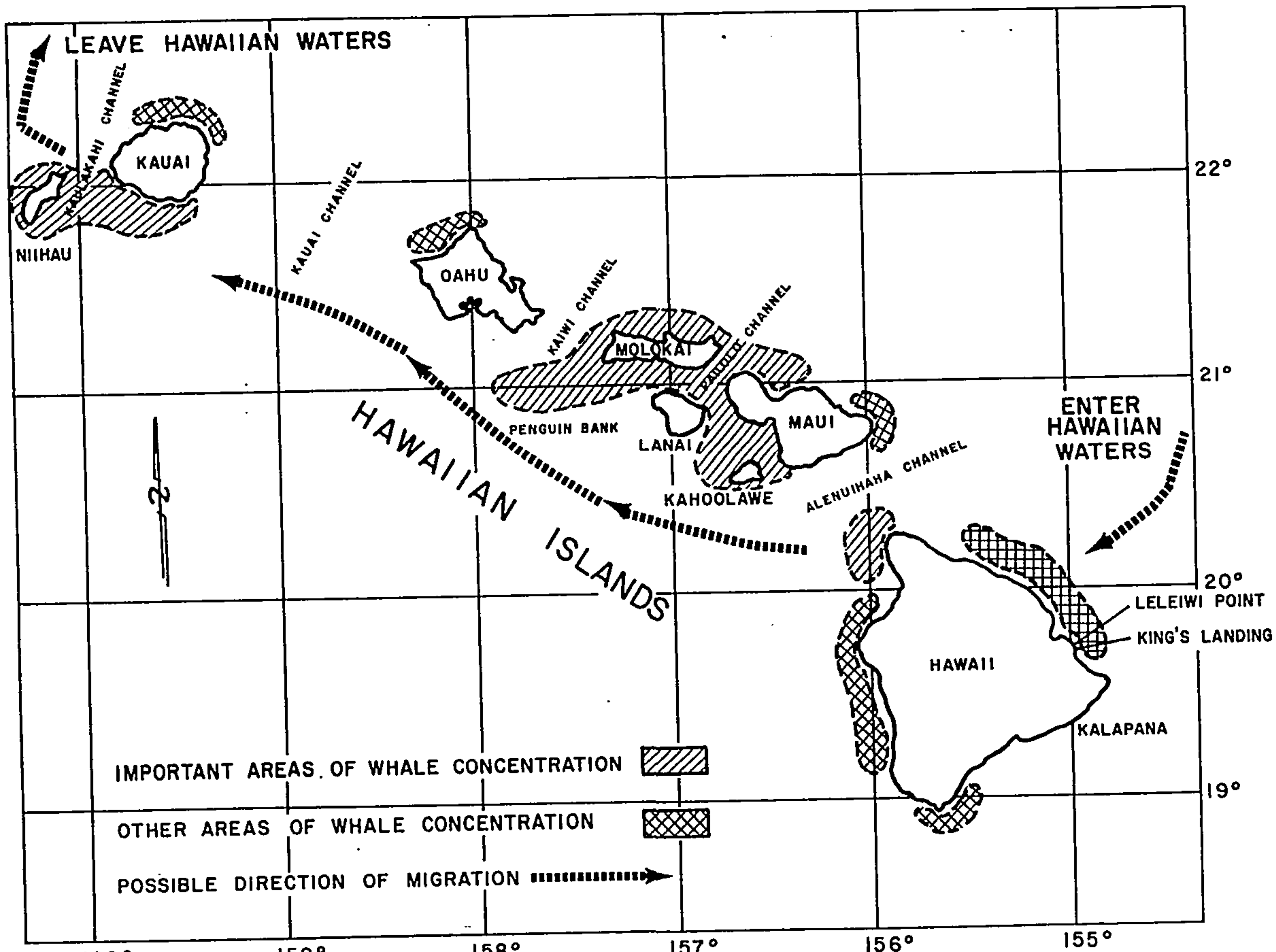


FIGURE B-2. DISTRIBUTION OF HUMPBACK WHALES IN HAWAII
ADAPTED FROM: WOLMAN AND JURASZ, 1976 AND RICE AND WOLMAN, 1977.
HERMAN IN WHITTEN, 1981.

(2) The humpback whale seasonally migrates through Hawaiian waters and can be found around all the major islands from Hawaii to Kaula Rock during the seasonal migration. The whales begin to appear during November and leave the islands by June with the greatest number occurring during February and March.

The National Marine Fisheries Service indicated that 500-700 whales annually migrate through Hawaiian waters to mate, calve and nurse their young. The whales prefer relatively shallow water, usually waters less than 100 fathoms deep, and are particularly numerous on Penquin Banks, in the area between Maui, Lanai, Molokai and Kahoolawe, around the northwest tip of Hawaii and between Niihau and Kauai. However, they are consistently seen in small numbers in other areas of the Hawaiian Islands during the season. Herman (1981) suggests that the whales first arrive in Hawaii around the island of Hawaii and travel northward toward the islands in Maui County and continuing toward Niihau and Kauai, where they leave on their return to the northern summer feeding grounds. The relative concentrations of whales in the Hawaiian Islands is illustrated in Figure B-2 based upon information provided in 1976 and 1977 census (Wolman and Jurasz 1976, and Rice and Wolman, 1977). The National Marine Fisheries Service provided the following whale census in the Leleiwi Point area of Hawaii. The whales have not been seen in Hilo Bay.

TABLE B-4. WHALE SIGHTINGS OFF LELEIWI POINT

Year	# Whales Sighted
1976	12
1977	7
1978	5
1979	9

(3) Wildlife Refuges. No wildlife refuges are established in the area.

(4) Marine Sanctuaries. No marine sanctuaries are established in the area.

(5) Migratory Waterbirds. The Hilo Bay area is not a major area of concentration for migratory shorebirds or waterbirds. However, migratory and domestic ducks have been observed in Waiakea Pond during the winter seasons. The most common waterbird in the Waiakea Pond is the domestic mallard.

(5) Wetlands. No wetlands are located along the Hilo Bay shoreline.

(6) Estuaries. Reed's Bay, Waiakea Pond, Wailoa River and the Wailuku River form small localized estuaries. These estuaries are not listed on the National Inventory of Estuaries.

f. Marine Resources.

(1) Hilo Bay is biologically depauperate, possibly the consequence of freshwater, siltation and turbidity stresses. The breakwater reduces the wave energy and water transport into the harbor, possibly allowing increases siltation in coral areas and reduce the mixing of marine and freshwaters masses. Freshwater stress prevents the establishment and growth of benthic marine communities on the reefs, and poor light penetration in water limits photosynthetic activity. The silt areas lack a developed infauna (Reference M & E Pacific, 1981). No live organisms were found in benthic samples taken from the silt areas probably as a result of recent maintenance dredging in the harbor. Six samples containing live organisms were obtained from rocky coralline areas in the bay. Scour and freshwater stress may be factors limiting benthic development in the Wailuku River mouth area.

(2) <u>Blonde Reef</u>: Live coral cover based on a survey of 5 sites in Hilo Bay ranged from 1-16% attaining the highest cover on Blond Reef (16%). The areas around Coconut Island had a live coral cover ranging from about 1-10% (M&E Pacific, 1980a). The surveyed detected a decline in coral cover between 1977 and 1980 possibly attributed to large floods in March 1980. Coralline algae, <u>Porolithon</u>, was more abundant than coral increasing its substrate coverage between 1977 and 1980. Porolithon is responsible for the consolidation of loose reef material and encrusting coral skeletons. Large dead coral heads on the reefs inside the breakwater suggest that the reef was once a viable ecosystem. Wave energy on the reef would have created a high energy environment that flushed silt from the reef and reduced salinity stress

by rapidly dissipating freshwater concentrations before the freshwater could affect the reef area. The wave action would have also created a high dissolved oxygen environment, and surge and wave currents would have promoted excellent water circulation over the reef, creating favorable conditions for coral growth. Areas within the breakwater exposed to waves refracted around the end of the breakwater have flourishing coral communities. The dead coral mass does provide habitat for fish and invertebrates and are areas of richness within the bay. The number of fish observed on the hard substrate habitat ranged from 4-365 fishes representing 3-29 species. For comparative purposes, areas seaward and to the east of the breakwater had coral cover ranging from 40-70% and fish numbers ranging from 172-543 fish representing 36-39 species (M&E Pacific, 1980b). Plankton densities in Hilo Bay, based upon 300 measurements, were not considered significantly different from other areas in the State, but were similar to ocean areas.

g. Fisheries.

(1) Fishermen believe fish stocks in Hilo Bay are declining (Reference Cheney, 1977) and attribute this reduction to a variety of factors including over-exploitation, removal of juveniles by bait fishermen, mechanical sugarcane harvesting and chemical pollutants. Whether or not a decline has actually occurred is unknown and the exact factors affecting fish abundance have not been determined. The inshore fish catch presently accounts for less than 10% of the total fish landings in Hilo Bay, and are represented by fewer species than offshore fish. This contrasts to earlier trends at the turn of the century, when inshore reef fish accounted for 50% of the total pounds of fish landed in Hilo Bay and represented more species caught than offshore fish. Nehu catches have declined and are presently insufficient to support a fishing fleet. The decline in nehu resources is attributed by fishermen to overfishing, nutrient and sediment loading and an overall decline of the tuna fishery. The Hawaii Island Chamber of Commerce, 1973, would like to see nehu of other bait resources improved in hopes of revitalizing the commercial fishing industry in Hilo. The principal nehu catch areas are located within the commercial port. Former baiting areas were along the Bayfront shoreline to Hoolii.

(2) The development of the bay as a commercial port, dredging and filling shoreline areas, and disposal of industrial and domestic wastes have affected the aquatic habitat and may have affected fishery resources. However, the long-term trend in fishing stocks and composition is unclear. Fishermen opinions concerning cause and effect relationships on local fishery stocks suggest that certain natural or man-related factors influence fish abundance and species, and the fishing methods used. For example, siltation probably fills habitat required by moi, aweoweo amd menpachi. Low stream flow and dry winters appear correlated to increased catch rates, but high stream flows usually correlate with increased papio catches. Murky water tended to increase ulua and moi catch rates, but reduced reef fish and nehu catches. High waves are thought to clear out the mud and improve fishing. The canec plant discharge into Waiakea Pond were thought to improve fishing. Good crabbing along the bayfront was associated with abundant Enteromorpha and Ulva growth. Chlorine from the sewage plant discharge was believed to be the cause of decline in piha (Spratelloides delicatulus) abundance. Shutting down and cleaning the sugar mills have resulted in a decrease in papio, ulua and moi catch and in an increase in menpachi, aweoweo, aku and other reef fish catch. Trawlers no longer foul their lines on rafts of bagasse. Turbid waters reduced spearfishing success and probably accounted for reduced reef fish catches.

h. Harvestable Shellfish Beds. None present.

i. Water Quality.

(1) Water quality in Hilo Bay has improved over the long-term with the removal and treatment of agricultural, industrial and domestic wastewater discharges. The pollutant sources have included wastewater from sugarcane and canec processing operations, raw sewage discharges, periodic shipboard waste disposal, cesspool overflow and leachates, surface runoff from agricultural lands, a thermal discharge, fish wastes, and petroleum wastes. At present, the major, point source discharges in Hilo Bay are the municipal sewage treatment plant discharge outside of the breakwater in Puhi Bay, and the Hilo Electric Company's Shipman power plant thermal discharge (28 mgd) into Wailoa River. The only sugar mill discharge in the area is located 8 miles north of Hilo Harbor entrance at Pepeekeo. The principal nonpoint pollution sources in

Hilo Bay are the surface runoff from agricultural lands and leachates from cesspools. Groundwater seepage and riverine discharge into Hilo Bay has a significant influence on bay water quality.

(2) Hilo Bay is a two-layered water body (M & E Pacific, 1980a) due to the discharge of 300 mgd of freshwater from Wailuku River and 700 mgd of groundwater into the harbor. The freshwater forms a distinct surface layer over the more saline bottom water. The surface layer persists throughout the year and is thicker in the wet season than in the dry season reflecting hydrologic conditions in the watershed. Salinity gradients are higher near the shore where groundwater discharges into the harbor and persist next to the breakwater, suggesting that the breakwater forms a barrier that inhibits mixing of marine and freshwaters.

(3) The predominant surface current direction is seaward out of the harbor. A continuous outflow occurs along the breakwater possibly as a result of groundwater outflow from Radio Bay. The surface current is dependent upon the influx of freshwater and the predominant wind direction. The influence of freshwater is measurable to a depth of 10 feet on Blonde Reef inside the breakwater and outside of the harbor mouth. In some areas the freshwater influence extends down to 20 feet. The depth of the freshwater influence generally reflects the low degree of mixing between the surface and bottom waters in the bay. The primary mixing force is provided by the wind with some mixing at the interface due to the shear force between the freshwater layer and the saline bottom water. Turbulence from ship traffic periodically mixes the two water layers. During certain periods (20% of the time) the prevailing wind direction is onshore retarding the outward flow of water on the surface. A two-cell circulation pattern was measured in 1973 (Reference Neighbor Island Consultants, 1973), but this condition may be the exception rather than the norm. Subsurface currents are influenced by the predominant westerly offshore coastal current off Blonde Reef (M & E Pacific, 1980a). Subsurface waters flow into Hilo Bay at a depth of 20-40 feet along the western side of the harbor mouth. Water continuously flows out of the harbor along the eastern side of the harbor mouth.

(4) Water quality baseline data are incomplete to compare annual variations with the State Water Quality Standards. The problem is due to water quality monitoring patterned after standards which were later revised in September 1979. The existing data are not reported in the same units of measurements contained in the new standards, and were not collected at a frequency sufficient to determine compliance with the new standards. In some instances the constituents analyzed are not the same as those required by the standards. The new standards classify Hilo Bay (inside the breakwater) as an embayment with marine water standards for a wet and dry season. Other types of water quality standards are further provided for artificial basins, reef communities and soft bottom areas within Hilo Bay. Data collected between March and June 1980 in comparison with the State Water Quality Standards indicate that turbidity, nitrate plus nitrite and total phosphorus exceed the geometric mean standard, and values for suspended solids, total kjeldahl nitrogen and chlorophyll-a exceeded standard maximum values (M & E Pacific, 1980). In general, Hilo Bay is vertically stratified due to freshwater discharges from surface and groundwater sources. Nutrient concentrations do not limit phytoplankton growth and do reflect seasonal fluctuations related to surface runoff and groundwater influx. Water temperatures are warmer in the surface waters than in subsurface waters, but solar heating can warm subsurface waters when the surface outflow is retarded. Suspended solids and turbidity fluctuate with seasonal water runoff and do not appear related to phytoplankton density. Subsurface seawater pH values are normal for seawater conditions and are higher than the freshwater surface layer. Generally, pH values are high when photosynthetic activity increases. Chlorophyll-a concentrations also fluctuate seasonally, being lower in the wet season when light water-penetration is reduced and when water turbidity is higher due to increased suspended solids. Dissolved oxygen levels are near saturation on the surface and attain super-saturated conditions in areas of high photosynthetic activity. Dissolved oxygen levels were lowest near the silty bottoms of the inner harbor and in Wailoa River probably due to reduced mixing with surface waters, to organic loading from terrestrial sources, and to organic material in the harbor that settles out of the water column. Fecal strep and fecal coliform bacteria concentrations have decreased over the past years with the removal of the sewage discharges, and are presently influenced by riverine and groundwater discharges. Fecal strep bacteria tend to survive longer in Hilo Bay than other areas in the State due to the freshwater layer in the harbor.

(5) Sedimentation. Water quality data indicate that sedimentation is a significant factor influencing water quality in Hilo Bay. The low wave energy environment created by the breakwater allows silt to settle out onto the coral reef environments smothering and destroying the reef ecosystem. The rate of sedimentation may be slow based on maintenance dredging records for Hilo Bay Harbor; approximately 54,000 cubic yards of material was removed from the harbor in 1977 reflecting the amount of material accumulated in the harbor since 1962. The estimated maintenance dredging cycle for Hilo Harbor is once every ten years based on past records. Silt is derived primarily from upland erosion within the Wailuku River drainage basin. Based on Table G-14, the principal sources of silt are the agricultural areas and the areas around the summit of Mauna Loa. However, about 35,000 tons of silt per year are deposited into Hilo Bay from Wailuku River (Corps of Engineers, 1976). Based on average annual rainfall in the region, significant soil losses are related to severe storm or intense rainfall events which affect severe erosion areas rather than smaller daily rainfall events. The rates of sedimentation in the harbor may be lower than in the past due to volcanism depositing new lava over erodible soils and to the termination of the sugar mill processing wastewater discharge into the harbor. The lava flow of 1881 covered some of the erodible soil in the Wailuku River drainage basin, and Wainaku Mill discharged 20,000 tons of suspended solids a year into the bay until it closed in 1976.

TABLE B-5. LAND-USES AND EROSION HAZARD OF THE WAILUKU RIVER DRAINAGE BASIN

Land-Use	Acres	Estimated Erosion Damage % Total Area	Estimated Erosion Damage (Tons/Acres/Year)
Urban	1,800	1.0	4
Sugarcane and Diversified Crops	3,900	2.5	7-11
Forest	77,500	46.5	0.2
Pasture	33,800	20.2	2-3
High Mountains Conservation	50,000	29.8	1-15

Source of Data: Hilo Comprehensive Study, Plan of Study, December 1976, Honolulu District, U.S. Army Corps of Engineers

(6) Sediment Quality. Pollutants discharged into Hilo Bay have left arsenic, PCB (Polychlorinated biphenyls), and pesticide contaminants in the bay sediments. A State Department of Health survey in 1978 indicated that arsenic, PCB and chlordane concentrations were found in significantly high amounts in Hilo Bay (State of Hawaii, 1978) in comparison with other sites surveyed in the state. The contaminants in dredged material may make the material unsuitable either for land or ocean disposal, and may require special handling or treatment of the material prior to disposal. Sand sediments from a shoal in the mouth of Wailoa River were found suitable for upland disposal following Environmental Protection Agency EP testing which indicated that pollutants did not leach from the sediment.

(a) Arsenic.

Based on the State survey, sediment samples from the Hilo Bay area contained total arsenic residues in concentrations ranging from about 22 ppm to 6370 ppm. A Canec plant, which manufactured canec boards from bagasse, discharged wastewater containing arsenic trioxide, a termicide, into Waiakea Pond. Sediments from the pond contain total arsenic residues in concentrations of about 6370 ppm. Sediments from the mouth of Wailoa River contained 131 ppm total arsenic, and sediments from Hilo Harbor contained total arsenic concentrations ranging from about 33 to 104 ppm. Total arsenic concentrations from sediments obtained from the outer part of the harbor ranged from about 22 to 33 ppm. The analysis indicated that arsenic migrated from Waiakea Pond into the bay environment. Arsenic concentrations in other Hawaiian estuarine sediments ranged from less than 4 ppm at Manele/Hulopoe, Lanai to about 20 ppm in Kaneohe Bay, and may reflect natural levels in Hawaiian soils. Analysis of fish and crab tissue indicates that arsenic is not bioconcentrating in the species tested.

(b) PCB.

Out of ten sites sampled in the State of Hawaii only two, Hilo Bay, Hawaii and Ala Wai Canal, Oahu, had measurable concentrations of PCB. Concentrations of PCB in Ala Wai Canal sediment ranged from 200 to 740 ppb with a mean of 372.6 ppb. The mean PCB concentration in Hilo Bay sediments was 200 ppm. The mean PCB concentration for other sample sites was less than 200 ppb. Under the test procedure the detectable limit was 200 ppb. No concentration of PCB was found in 27 biota samples analyzed.

(c) Chlordane.

Hilo Bay sediments also contained measurable quantities of chlordane. The sum of the mean values of three derivatives of chlordane was 84.2 ppb and was one of four sites in Hawaii found to have chlordane present in the sediments. Sediment from six other sites contained no chlordane residues above the detectable limit of 10 ppb. The levels of chlordane residue in mullet flesh from Waiakea Pond ranged from 80-160 ppb. No mullet from Hilo Bay was analyzed. The mullet viscera contained chlordane residue 3 to 4 times higher than the flesh. The mean concentration of chlordane residue in Hilo sediment was considerably lower than the range of mean concentrations of chlordane residue (about 296 to 567 ppb) found in the Ala Wai and Kapalama canals.

SUPPORTING DOCUMENTATION

ENGINEERING INVESTIGATIONS AND DESIGN

ENGINEERING, DESIGN AND COST

TABLE OF CONTENTS

TITLE	PAGES
DESIGN ANALYSIS	
General Criteria	
a. Formulation and Analysis	1
b. Technical Criteria	1
c. Federal Design Feature	1
d. Level of Design Analysis	1
Site Location	
a. Hilo Bay	1
b. Port of Hilo	2
Climatology	
a. Local Climatology	2
b. Tropical Storms and Hurricanes	3
Water Level and Currents	
a. Tides	3
b. Astronomical Tide	4
c. Atmospheric Pressure Drop	4
d. Storm Surge	4
e. Design Stillwater Level	5
f. Currents	5
Wave Conditions	
a. Wave Climate	6
b. Refraction Analysis	8
c. Breaking Wave Condition	9
Wave Conditions in Hilo Bay	
a. Forecasting for Shallow Water Waves	10
b. Diffraction-Refraction Analysis	11
Design Wave Heights	11
Plan Design - Circulation Improvement	12
COST ESTIMATE	
Basis For Estimate	13
Project First Cost	14

LIST OF PLATES

Plates	Title	Follows Page
D-1	Wind Diagram	3
D-2	Design Wave Height for Applicable Areas	10
D-3	Typical Dolo Breakwater Section	15

LIST OF TABLES

Table	Title	Page
D-1	State Facilities, Port of Hilo	follows page 2
D-2	Hilo, Hawaii Climatology	follows page 3
D-3	List of Significant Tsunamis Since 1946	7
D-4	Diffraction - Refraction Analysis	follows page 11
D-5	Design Wave Heights	12
D-6	Crest Elevation, Layer Weight and Layer Thickness for Circulation Improvement Breakwater	13

1642B

DESIGN ANALYSIS SECTION

1. GENERAL CRITERIA

a. FORMULATION AND ANALYSIS. The formulation and analysis of the alternative plans were based on the Water Resources Council's Principles and Standards, and applicable Corps regulations and guidelines on planning process.

b. TECHNICAL CRITERIA. The following technical criteria were adopted for use in developing alternative plans:

(1) The inner harbor basin should provide a safe maneuvering area for the design vessel, with provisions for berthing.

(2) Local plans for land use and port expansions area will be considered.

c. FEDERAL DESIGN FEATURE. The Federal design feature will consist of a new stub breakwater to protect the inner harbor basin.

d. LEVEL OF DESIGN. The appendix contains supporting engineering data and analysis to support the Stage 3 formulation and the plan selection process.

2. SITE LOCATION

a. HILO BAY. The study area was limited to the triangular shaped Hilo Bay at approximately 19.7° north latitude and 155.1° west longitude (Figure 2 of main report) on the northeast coast of the island of Hawaii. The south and east shores are relatively flat and at low elevations, while the west shore is rocky, nearly vertical cliffs. The entrance to the bay separates the cliffs and a coral reef, known as Blonde Reef, is about 1 mile wide with a maximum depth of 60 feet.1/ Blonde Reef extends about 2 miles northwesterly from the southeast side of the bay, with depths varying from 6 to 18 feet. The reef and the existing 10,080-foot long rubble mound breakwater affords storm wave protection to the inner bays. The inner bay includes Kuhio, Radio and Reeds Bays (Figure 3 of main report). Kuhio Bay serves as the deep draft harbor turning basin which is 1,400 feet wide, 2,300 feet long and 35 to 40 feet deep. The port area is located in the southeast end of the bay at the root of the 10,080-foot long breakwater. Two small rivers enter Hilo Bay: The Wailuku River adjoining the bluffs on the west, and the Wailoa River on the south. Published maps of the study area and vicinity are listed in the following tabulation:

Description	Prepared by	Chart No.
Hawaiian Islands	National Oceanic and Atmospheric Administration National Ocean Survey (N.O.A.A.)	19004
Island of Hawaii	N.O.A.A.	19320
Hilo Bay	N.O.A.A.	19324

b. PORT OF HILO. The port facilities at Hilo are on state-owned land under the jurisdiction of the Department of Transportation, Harbors Division. The facilities at Kuhio Bay are used for handling general and bulk cargo, and the one at Radio Bay is used for mooring small transit vessels. Table D-1[2] is a tabulation of the physical characteristics of the State's facilities at the Port of Hilo.

3. CLIMATOLOGY

a. LOCAL CLIMATOLOGY. The average annual temperature at Hilo is 73°F. The highest average monthly temperature is 76°F in August and September and the lowest average monthly temperature is 71°F for January to March. Owing to the moderate influence of the bay and the ocean, extreme temperatures are of short duration and range from a record low of 53°F to a high of 94°F. Within

1/ All elevations referenced to mean lower low water datum (MLLW), unless stated otherwise.
2/ Development Plans, Port of Hilo and Port of Kawaihae, Island of Hawaii, Tudor Engineering Company, August 1972.

the city of Hilo itself, average rainfall varies from about 130 inches a year near the shore to as much as 200 inches in mountain sections. The wettest part of the island, with a mean annual rainfall exceeding 300 inches, lies about 6 miles upslope from the city limits. Rainfalls on about 280 days a year in the Hilo area. Temperature and precipitation data compiled by the Department of the Naval Oceanography Command Detachment, Barbers Point, Hawaii for the period 1946 to 1979 are shown on Table D-2. The wind velocity and direction table shows that winds approach Hilo Bay primarily from the southwest (SW) and west southwest (WSW) directions, rather than the typical northeasterly trade direction for the islands. Winds are predominantly from the SW and WSW during the night and early morning hours, with winds generally shifting to the typical trade direction by late morning. A wind diagram for the years 1965-1974 from the gage located at General Lyman Field is shown on Plate D-1.

b. TROPICAL STORMS AND HURRICANES. Although extremely rare in the Hawaiian Islands, tropical storms and hurricanes have and do, from time to time, affect the islands. Tropical storms are defined as having sustained windspeeds between 34 and 63 knots, while hurricanes are defined as storms with sustained windspeeds equal to or greater than 64 knots. Based on information from the US Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) National Weather Service, from 1950 to 1978 at least fourteen tropical storms or hurricanes have passed within 500 miles of the state. Tropical storms and hurricanes which impact on sea and weather conditions in Hawaii generally occur during the summer months. Hurricanes "Dot" in 1959 and "Iwa" in 1982 have caused severe damages, primarily on the islands of Kauai and Oahu. Damages on the island of Hawaii were minimal.

4. WATER LEVEL AND CURRENTS

a. TIDES. The tidal data shown below were obtained from the U.S. Coast and Geodetic Survey and are referenced to Mean Lower Low Water (MLLW). All elevations in this appendix are referenced to MLLW datum.

	Feet
Highest Tide Observed	3.8
Mean Higher High Water	2.4
Mean High Water	1.9
Mean Tide Level	1.1
Mean Low Water	0.3
Mean Lower Low Water	0.0
Lowest Tide Observed	-1.6

b. ASTRONOMICAL TIDE.

The astronomical tide is estimated to be about equivalent to the mean higher high water or 2.4 feet.

c. ATMOSPHERIC PRESSURE DROP.

The water level rise due to atmospheric pressure is calculated by:

$$S_p = 1.14\,(P_n - P_o)\,(1 - e^{-R/r}) \qquad \text{EQ. 3-85, SPM}^{3/}$$

Assuming parameters of hurricane Fico, 1978

P_n = 29.92 inches

P_o = 28.20 inches

R = 25 nautical miles

r = 100 nautical miles

S_p = 0.4 feet

d. STORM SURGE.

The water level rise due to storm surge is calculated by:

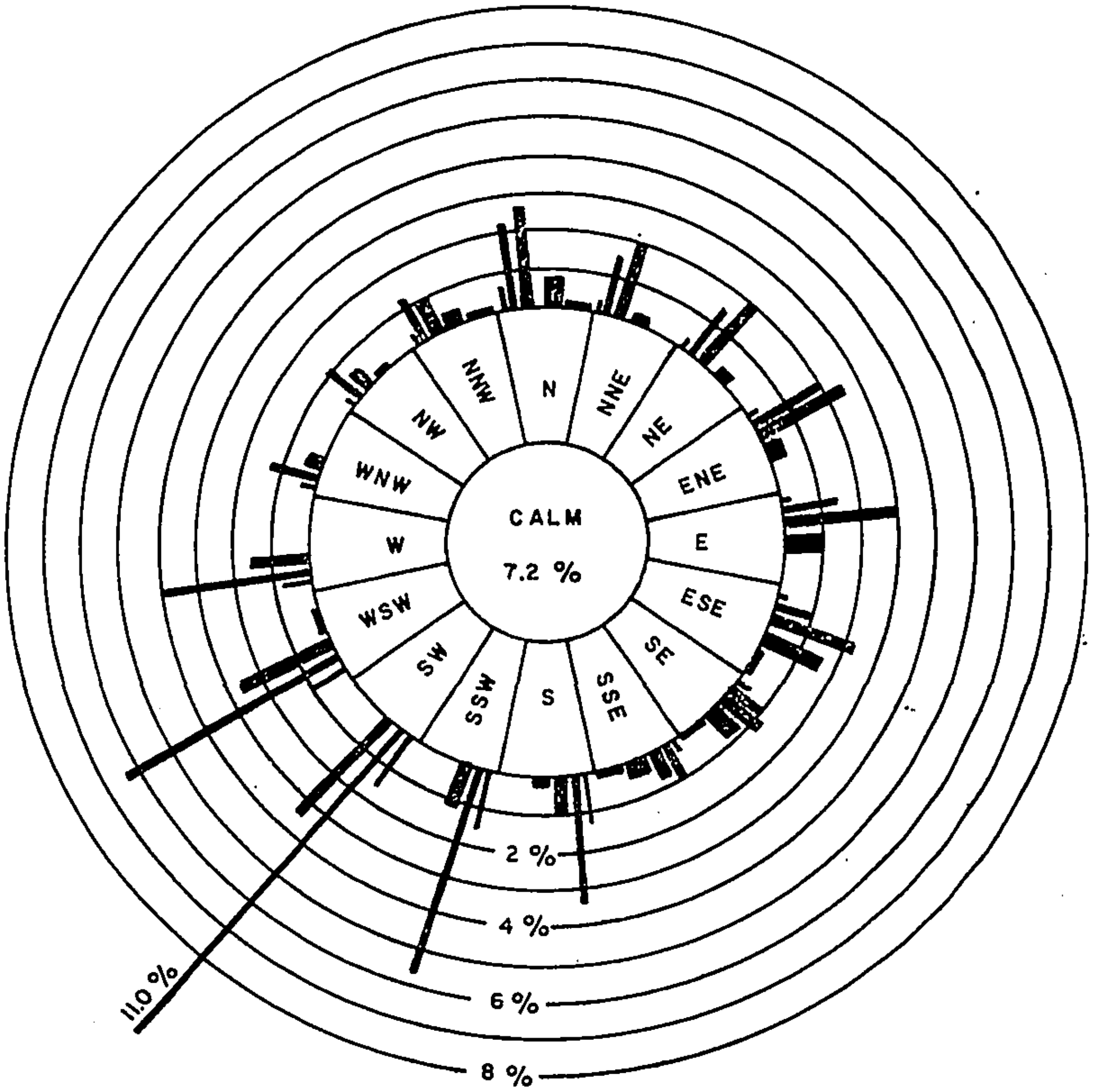
Storm surge = S_i, where S_i is the incremental rise in water level due to wind stress perpendicular to the bottom contour

$$S_i = \frac{540 K\, U_R\, X}{\bar{d}} \qquad \text{(TR-4, 1-64)}\ ^{4/}$$

3/ U.S. Army Coastal Research Center, Shore Protection Manual, 3rd Edition, 1977.

4/ U.S. Army Coastal Research Center, Technical Report No. 4, 3rd Edition, 1966.

GENERAL LYMAN FIELD
HILO, HAWAII



NOTE: THE PERCENTAGES AND THE DIRECTIONS ARE AVERAGES DURING THE 10 YEAR PERIOD, 1965 TO 1974 INCLUSIVE.

LEGEND:

- 0-3 KNOTS
- 4-6 KNOTS
- 7-10 KNOTS
- 11-16 KNOTS
- OVER 16 KNOTS
- —8%— TOTAL % OF YEAR

SOURCE - HONOLULU DLNR, DOWALD

HILO, HAWAII HAWAII

WIND DIAGRAM

U.S. ARMY ENGINEER DISTRICT, HONOLULU

X = total distance in N.M.

$K = 3.0 \times 10^{-6}$

U_R = 62 knots

ΔX = incremental distance in N.M.

d = mean depth over increment (FT)

d_i = initial depth

Storm surge in the study area is estimated to be in the neighborhood of 0.5 feet for the July 1978 hurricane Fico.

e. DESIGN STILLWATER LEVEL. The design stillwater level (SWL) during hurricane conditions consists of (1) astronomical tide, (2) the rise due to atmospheric pressure drop, and (3) the rise due to storm surge.

(1)	Astronomical Tide	+2.6 ft.
(2)	Atmospheric Pressure Drop	+0.4 ft.
(3)	Storm Surge	+0.5 ft.
	SWL =	+3.5 ft.

f. CURRENTS. The "Geological, Biological and Water Quality Investigations of Hilo Bay," prepared by M and E Pacific, Inc., Environmental Engineers for the Honolulu District Corps of Engineers in September 1980, provides a general understanding of the circulation pattern in Hilo Harbor. The following findings are presented:

(1) The freshwater discharge into Hilo Harbor has a profound influence in the circulation pattern by the creation of a vertical stratification of the water column.

(2) Wind stresses have significant influences on the surface layer.

(3) A net seaward flow occurs in the surface layer of the water column, while the bottom layer responds primarily to the tide.

(4) Subsurface flows at the harbor mouth are primarily influenced by tide. During periods of flood tide, subsurface flow is generally inshore (southerly) across the entire mouth of the harbor.

During periods of ebb tide, the subsurface flow is generally outward (northerly) across the entire mouth of the harbor.

Surface flows in the harbor are influenced primarily by the wind stresses and by the general outward gradient of the surface layer.

(5) Surface flows at the entrance to Kuhio Bay (turning basin) are influenced by wind stresses. The surface flow is generally in the direction of the wind with an easterly counterflow at the 5-foot depth.

During flood tide, current speeds averaged 0.08 knots. During ebb tide, current speeds averaged 0.07 knots.

(6) Inner harbor (pier-Baker's Beach). The current speed in the subsurface layer averaged 0.05 knots during ebb and 0.02 knots during flood tide.

5. WAVE CONDITIONS.

a. WAVE CLIMATE.

Waves arriving at Hilo Bay are generated in the northeastern sector of the Pacific Ocean, ranging from the Aleutian Islands in the north to South America. Three primary wave types affect the study area. These three types are (a) the east-northeast trade waves, (b) the northern swell, and (c) the tsunami.

LOCAL WIND WAVES. East-northeast trade waves may be present throughout most of the year, but are most frequent between May and September, the summer season, when they usually dominate the local wave spectrum. They result from the strong trade winds blowing out of the northeast quadrant over long fetches of open ocean. Typically, these deepwater waves have periods ranging from 6 to 10 seconds and heights of 4 to 12 feet. Generally, east-northeast trade waves are present from 80 to 90 percent of the time during the summer season, and from 60 to 70 percent of the time during the remainder of the year.

NORTHERN SWELL. Northern swell is generated in the north Pacific Ocean by winter storms. Waves may typically have periods of 10 to 15 seconds, and heights of 5 to 15 feet. Some of the largest waves reaching the Hawaiian Islands are of this type. Northern swell usually occurs during the winter season of October through April.

TSUNAMI. Tsunamis are impulse-generated water waves caused by catastrophic geological occurrences within an ocean basin. The orientation of the triangular-shaped bay at Hilo makes this port city very susceptible to tsunami attacks from the eastern half-circle of the seismic belt extending from the Aleutian Islands down to the west coast of South America. In several tsunami occurrences (Table D-3) at Hilo, the waves were transformed into bores which devastated large areas of the city and harbor.

TABLE D-3. LIST OF SIGNIFICANT TSUNAMIS SINCE 1946 5/

Date	Origin of Tsunami	Distance and Direction from Hawaii	Time of Arrival and Travel Time	Largest Wave Reported (Feet)
1 Apr 46	Aleutian	2000 nautical miles due north	Hilo 0645 4 hrs 55 min	30
4 Nov 52	Kamchatka	2600 nautical miles northeast	Hilo 1335 6 hrs 37 min	12
9 Mar 57	Aleutian	2000 nautical miles northwest	Hilo 0911 4 hrs 49 min	14
22 May 60	Chile	6600 nautical miles southeast	Hilo 1024 14 hrs 47 min	35
28 Mar 64	Alaska	2350 nautical miles north-northeast	Hilo 2300 5 hrs 24 min	10
29 Nov 75	Local	--	Hilo 0512 24 min	8.5

5/ Loomis, H. G. 1976 Tsunami Wave Runup Heights in Hawaii, HIG-76-5, Hawaii Institute of Geophysics, University of Hawaii, Honolulu.

The most recent tsunami, which occurred on 29 November 1975, was unique because it was generated locally by a large scale land subsidence which occurred during an earthquake centered off the southeast coast of the island of Hawaii. This earthquake measured 7.2 on the Richter scale. The tsunami caused runups of about 10 feet along much of the Hilo District. In Hilo, the water level dropped with the recession of the first tsunami. The USS Cape Small, a Coast Guard cutter moored in Radio Bay, settled to the muddy bottom and began to list to one side. A series of waves surged in and out of the bay at approximately 15-minute intervals, smashing some small boats and washing others into docks; four boats were sunk and three damaged.6/

Adverse impacts resulting from locating in the tsunami flood zone include the risks of destruction of property and loss of life. The proposed action will require development in the inundation zone such as harbor backup facilities. There is no alternative location for these facilities, however, utilizing construction practices which meet requirements of the National Flood Insurance Program will minimize tsunami damages. Adverse impacts resulting from increased use of the tsunami flood zone can be minimized by adequate tsunami warning. A State-wide tsunami warning system is presently in existence. The harbor can be evacuated in the event of a tsunami warning. Boats would not reenter the harbor until the tsunami warning has been cancelled.

b. REFRACTION ANALYSIS.

Analyzed previous wave refraction studies for deepwater waves approaching from the North, N.22.5°E., and N.45°E. directions. These directions were selected after evaluating the wave exposure regime for the study area. Deep-water storm waves were analytically transformed considering refraction and shoaling to shallow water wave heights at the entrance to Hilo Bay. Refraction analyses for the various wave approach directions studied indicated that the critical direction for storm waves at Hilo Harbor is north northeast. The

6/ Cox, D.C. and J. Morgan, 1977 Local Tsunamis and Possible Local Tsunami in Hawaii, HIG-77-14, Hawaii Institute of Geophysics, University of Hawaii, Honolulu.

computed wave heights for a storm approaching from N.22.5°E were higher than any other direction. Based on a deepwater wave height of 27 feet[7/] and a wave period of 17 seconds, the maximum theoretical storm wave height incident to the entrance of Hilo Bay was computed according to SPM equation 2-77:

$$\frac{H}{H_0} = K_R K_S$$

$$H = H_0 K_R K_S$$

where H = wave height in any depth
H_0 = wave height in deep water = 27 feet
K_R = refraction coefficient = 0.81
K_S = shoaling coefficient = 1.30
H = 28.4 feet

c. BREAKING WAVE CONDITION.

Assuming a wave period of 17 seconds to be characteristic of the largest storm wave, seaward bottom to have a slope m = 0.00 and H_b = 28.4 feet.

Breaker depth (d_b) from SPM figure 7-2 is:

$$\frac{H_b}{gT^2} = \frac{28.4}{32.2(17)^2} = 0.0031$$

$$d_b(max) = H_b = 1.5\ (28.4) = 43 \text{ feet}$$

$$d_b(min) = H_b = 1.28\ (28.4) = 36 \text{ feet}$$

Breaker travel distance (x_p) from SPM EQ 7-3

$$x_p = p\ H_b = [4.0 - 9.25m]H_b = 114 \text{ feet}$$

7/ U.S. Army Engineer District, Honolulu, Corps of Engineers, Technical Report No. 1, 1977.

Based on the foregoing calculations, the design storm wave of 28.4 feet will be fully broken seaward of the 30-foot contour. Thus, the design wave for the harbor structures in the bay must be based on the largest wave generated by either wave forecasting for shallow water or diffraction-refraction analysis performed in accordance with procedures, techniques and diagrams described in the SPM.

6. WAVE CONDITIONS IN HILO BAY.

a. FORECASTING FOR SHALLOW WATER WAVES. The wave heights and periods for various wind directions, fetch lengths and average constant depths are tabulated from SPM Figures 3-25, 3-26, 3-27, 3-28, and 3-29.

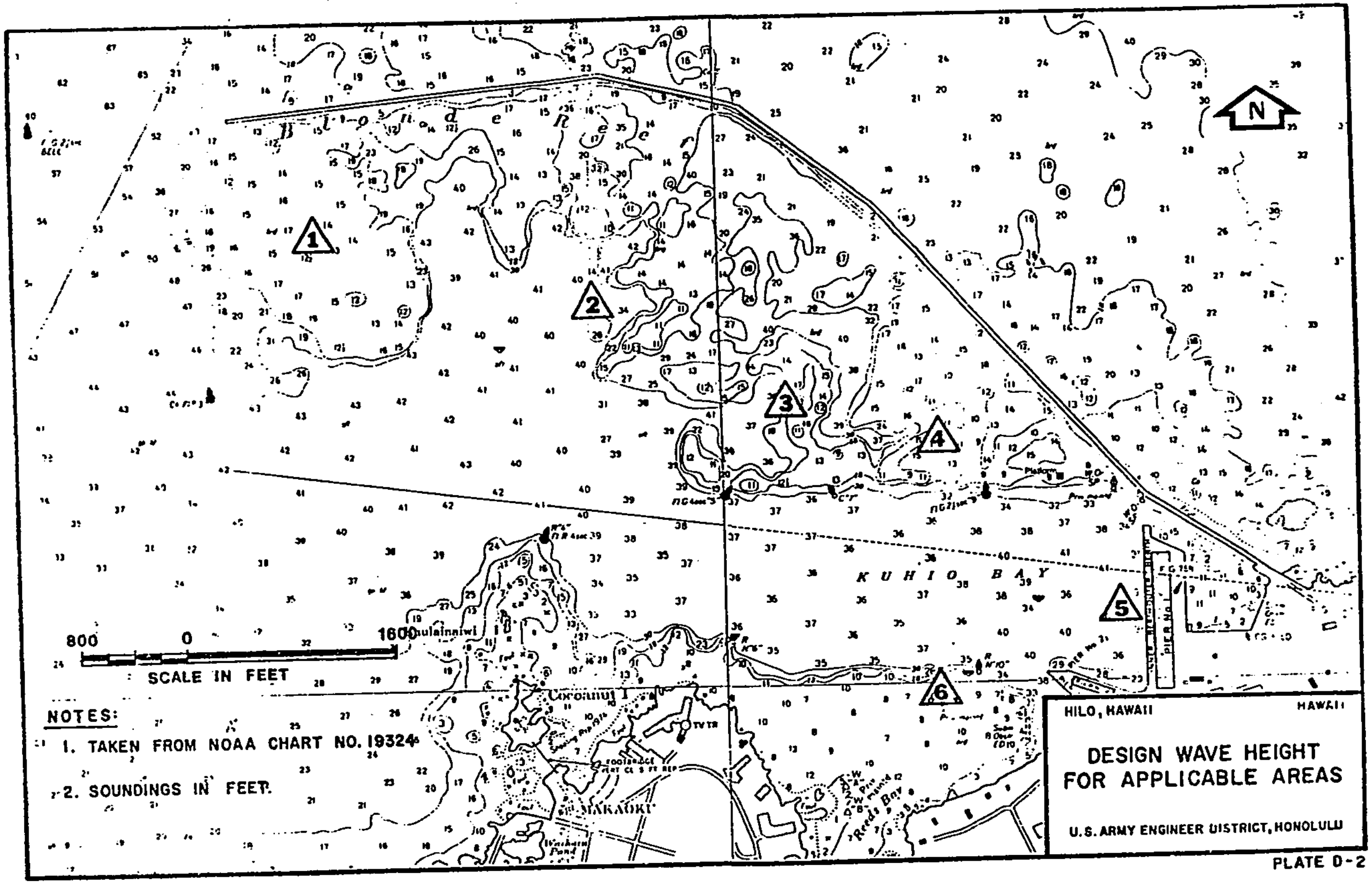
Location of Improvements (Plate D-2)	Wind Direction	Fetch (Feet)	Average8/ Constant Depth (Feet)	U (MPH)	H_f (Feet)	T_f Second
1	East	4300	20	75	3.2	4
	Southeast	6700	20	75	3.8	4
	South	5200	20	75	3.5	4
	Southwest	5400	20	75	3.5	4
	West	5400	20	75	3.5	4
2	East	5000	20	75	3.5	4
	Southeast	4600	20	75	3.3	4
	South	2500	35	75	3.0	4
	Southwest	6300	30	75	4.0	4
	West	6700	30	75	4.1	4
3	East	1700	15	75	2.3	3
	Southeast	2900	20	75	2.8	3
	South	2100	20	75	2.5	3
	Southwest	7500	30	75	4.2	4
	West	8800	35	75	4.5	4
4	East	800	15	75	1.8	2
	Southeast	1700	20	75	2.5	3
	South	1700	20	75	2.5	3
	Southwest	3300	20	75	3.0	3
	West	8300	30	75	4.0	4
5	West	4200	35	75	3.5	4
	Northwest	10000	35	75	4.8	4
6	North	3300	20	75	3.0	3
	Northeast	2100	25	75	2.5	3
	Northwest	5000	35	75	3.8	4

8/ Includes design SWL (3.5 feet).

b. DIFFRACTION-REFRACTION ANALYSIS. The previous theoretical wave diffraction-refraction studies were also analyzed, the incident wave perpendicular to the tip of the existing Hilo breakwater is assumed to be the maximum nonbreaking wave of 16.8 feet based on controlling depth of 21.5 (18 feet plus SWL) feet, m = 0.00. The results of the diffraction-refraction analysis are tabulated in the following Table D-4.

7. DESIGN WAVE HEIGHTS.

Design wave heights are based on the largest wave generated by either wave forecasting for shallow water or diffraction-refraction analysis. Table D-5 shows the design wave heights and wave periods obtained at areas of improvements in Hilo Bay.



NOTES:

1. TAKEN FROM NOAA CHART NO. 19324
2. SOUNDINGS IN FEET.

HILO, HAWAII HAWAII

DESIGN WAVE HEIGHT FOR APPLICABLE AREAS

U.S. ARMY ENGINEER DISTRICT, HONOLULU

PLATE D-2

TABLE D-5. DESIGN WAVE HEIGHTS

Area of Improvement (see Plate D-2)	Wave Height, H (feet)	Wave Period (seconds)	Depth of Structure, ds (feet)		
1	10.1	14	18.5	nonbreaking	wave
2	4.1	4	18.5	"	"
3	4.5	4	18.5	"	"
4	4.0	17	15.5	"	"
5	4.8	4	38.5	"	"
6	4.1	14	11.5	"	"

8. PLAN DESIGN - CIRCULATION IMPROVEMENT.

In order to improve circulation over Blonde Reef and in Hilo Bay a design analysis was made to evaluate the feasibility of reducing the effectiveness of the outer 7,500-feet of the existing breakwater. This required consideration of a new, shorter breakwater to protect the inner harbor (Figure 4 of main report).

(1) DESIGN WAVE HEIGHT. Calculation of the design wave height was based on the controlling depth criteria. Based on this criteria and the fact that the reef flat fronting the structure has a 0.00 nearshore slope, the design wave height is equal to 0.78 times the depth of water. Using a SWL of 3.5 feet and depth at toe of structure of -14 feet, a controlling depth of 17.5 feet was obtained. The design wave was computed to be 13.7 feet.

(2) DIFFRACTION ANALYSIS. Wave diffraction analyses were analyzed to aid in determining the length of the breakwater and in estimation of wave height reduction in the vicinity of Hilo dock. A wave crest orientation of 90° was selected assuming the existing breakwater seaward of the circulation improvement plan is allowed to deteriorate naturally. Based on the diffraction analysis, the estimated wave height at Hilo docks will be about 10 percent of the incident wave height at the breakwater head.

(3) BREAKWATER. The crest elevation, weight and thickness of the dolosse and stone layers for the breakwater are shown on Table D-6. Typical breakwater sections is shown on Plate D-3.

TABLE D-6. CREST ELEVATION, LAYER WEIGHT AND LAYER THICKNESS FOR THE CIRCULATION IMPROVEMENT BREAKWATER

		Armor Layer		Underlayer		Core Material
Location	Crest Elevation (Feet)	Design Dolosse Weight	Layer Thickness (Feet)	Design Stone Weight (Pounds)	Layer Thickness (Feet)	Design Stone Weight (Pounds)
3	+15.0	4 ton	7.6	600 to 1000	3.9	Spalls to 100

COST ESTIMATE

1. BASIS FOR ESTIMATE

General

a. Estimated quantities were based on existing topograhic and hydrographic maps and surveys and typical plans and section.

b. Estimated construction period and 12% of cost growth is included in the unit cost.

c. Oahu based contractor will do the construction.

d. A 20% contingency cost allowance.

e. All unit prices include factor for waste.

f. September 1983 price levels.

g. The harbor will operate during construction period.

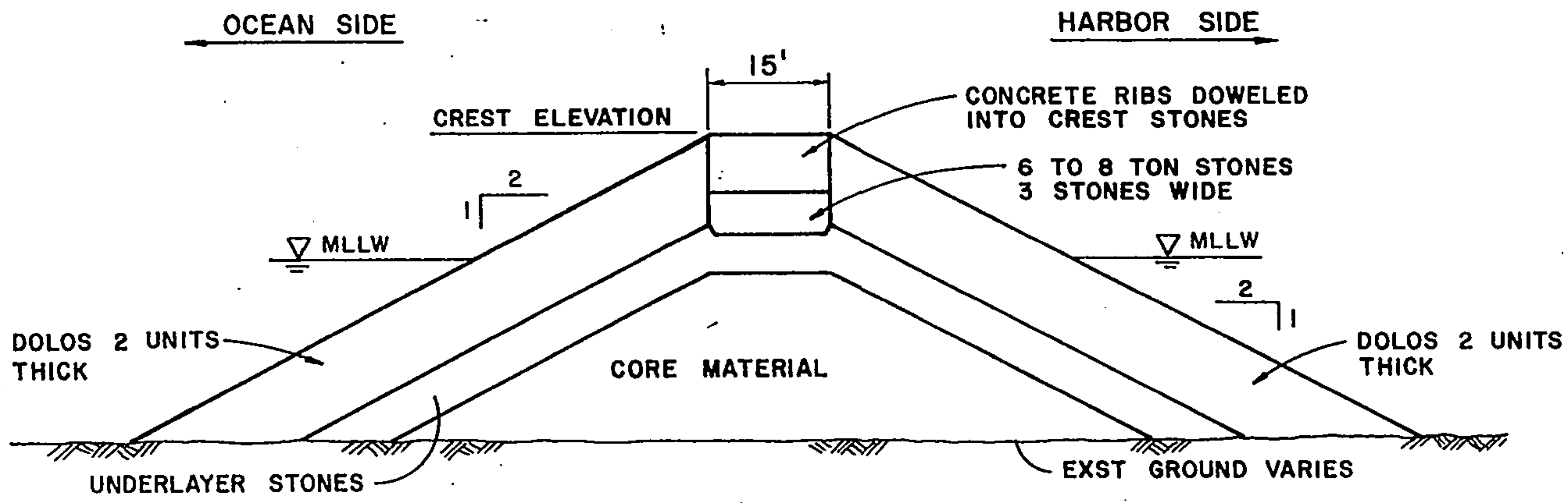
h. Equipment working on breakwater with steel angle running inside of crane tracks for stability.

i. A 100' x 200' staging area will be built at sta 0+00 of new breakwater. Equipment will be parked in staging area at night.

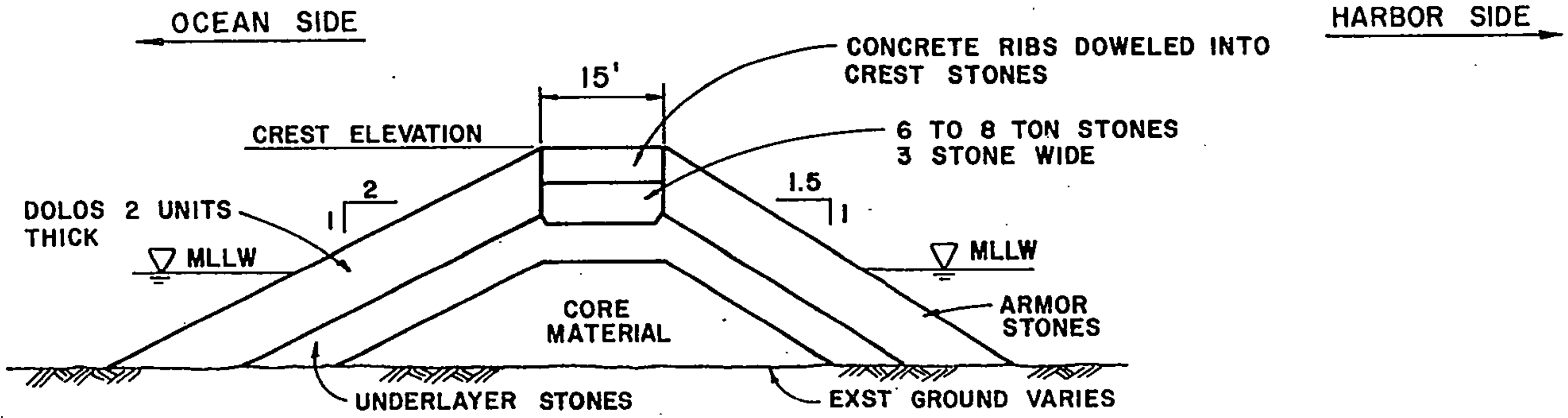
j. Estimated construction period two years.

d. PROJECT FIRST COST - CIRCULATION IMPROVEMENT

Item	Unit Cost Quantity	Subtotal Cost ($)	Total Cost ($)	($)
FEDERAL COST				
Mob and Demob	LS	-	600,000	
Breakwater				
Develop Quarry	LS	-	265,000	
Workload & Staging Area	LS	-	230,000	
Armor 7-Ton Cap	5,600 CY	70.35	394,000	
4-Ton Dolos	5,500 Ea	315.00	1,734,000	
3-5 Ton Stones	33,400 CY	81.00	2,705,000	
500-1000 lb Stones	24,400 CY	63.00	1,537,000	
1-150 lb Stones	59,300 CY	49.20	2,919,000	
				10,384,000
CONTINGENCY 20%				2,077,000
TOTAL FEDERAL COST				12,461,000
NON-FEDERAL COST				0
TOTAL FIRST COST				12,461,000



TYPICAL DOLO BREAKWATER SECTION
(OVERTOPPING CONDITION)



TYPICAL DOLO BREAKWATER SECTION
(MINOR OVERTOPPING)

PLATE D-3

SUPPORTING DOCUMENTATION

GEOLOGY

GEOLOGY
HILO AREA COMPREHENSIVE STUDY
BREAKWATER IMPROVEMENT

Regional Geology

The island of Hawaii, the largest of the Hawaiian Archipelago, covers an area of over 4,000 square miles. The island was formed during the last 800,000 years by the gradual emergence and subsequent coalescence of five volcanoes; Mauna Loa and Kilauea, which are still active, Hualalai, which last erupted in 1801, Mauna Kea, which has been inactive in recent geologic time, and Kohala, which has been extinct for eons.

The volcanic mountains are generally oval and dome-shaped. Mauna Loa is 75 miles long and 64 miles wide, rising from a base 15,000 feet below sea level to 13,680 feet above sea level. It is the largest active volcano and is considered the biggest single mountain on earth. Its volume is about 10,000 cubic miles. Mauna Kea is 50 miles long and 25 miles wide. Its volume is about 7,500 cubic miles. These huge mountains have been formed almost entirely by the accumulation of thousands of thin flows of lava, each separate flow averaging less than ten feet in thickness. The broad, smooth, dome shapes have given rise to the name of "shield" volcanoes. Nowhere are the lower slopes of the mountains steeper than twelve degrees with the average slope around six degrees. Gentle, flat slopes extend outward beneath the water to the sea floor.

Site Geology

The city of Hilo and the breakwater are located where the lower slopes of Mauna Loa and Mauna Kea merge. The surface of the ground in South Hilo, Waiakea District, has a gentle, flat slope northward toward the ocean of one foot in 400 feet, or less than one degree.

Hilo Bay is a broad indentation in the northeastern coastline of the island, created by the Hamakua volcanic series of Mauna Kea and the Ka'u volcanic series of Mauna Loa. Recent scoriaceous, black lava flows from Mauna Loa have formed the entire central and southern half of the bay. Older flows from Mauna Kea have made vertical, high, wave-cut cliffs along the north side of the bay. The existing breakwater structure is built on a coral-limestone reef (called Blonde Reef) over lava. Marine sediments consisting of fine and medium grained basalt sand and silt with some fragments of coral limestone, cover the narrow beach and form the ocean floor in shallow water.

The site of the proposed harbor improvements is located on the east side of the bay near the port of Hilo's docking facilities. The north side of the site is bound by the existing rubble-mound breakwater which was constructed on the Blonde Reef. The Blonde Reef is a mass of coral limestone fragments consisting of a mixture of loose to compact silt, sand and gravel sediments submerged in 10 to 20 feet of water. This reef extends in a northwest direction from the eastern bay shoreline to approximately the middle of the bay. The project area is bound on the south by the shoreline of the southeastern portion of the bay. Recent lava basalt outcrops (about 5,000 years of age) line the bay's southeast shore, suggesting that lava basalt is shallow below the ground surface adjacent to the southern boundary of the harbor turning basin. The western limit of the project area is the entrance channel to the port facility. Most of the area to the south of the proposed breakwater structure has been dredged to a depth of -35 to -40 feet (MLLW) and has been named Kuhio Bay.

Subsurface Investigations

Geotechnical subsurface investigations have not been made specifically for the proposed breakwater improvement. The subsurface data contained in this report has been obtained from parts of three separate sources and are described below. These sources are (1) the subsurface investigations for the design and

and construction of Hilo Harbor made in 1923, (2) for the design of the Hilo Tsunami Protection Project made in 1967, and (3) for water and land resources development in the Hilo Comprehensive Study made in 1980. Because of the differing nature and purposes of these sources, only data relative to the proposed breakwater improvement is presented in this section.

(1) Borings for Hilo Harbor, 1923

Wash borings for engineering investigations for the design and construction of Hilo Harbor were made in 1923 by A. H. Hobart and are presented as Plated G-1. Information from this source is used with a high degree of reservation for several reasons. A lack of confidence in the quality of information is generated because 1) wash borings generally do not provide satisfactory samples for material classifications, 2) wash borings generally do not provide an adequate indication of the physical and engineering properties of subsurface materials, 3) drilling and sampling methods in 1923 were considered state-of-the-art and are not equal to modern drilling techniques, and 4) the quality of equipment and personnel performing the borings and material classifications are unknown. However, the data is useful in cases where no other data exists, but only as a very general indication of material type.

(2) Borings for Hilo Tsunami Protection Project, 1967

Four (4), 2-inch nominal diameter split barrel drive sample and NX core borings completed in 1967 during the subsurface investigations for the Hilo Tsunami Protection Project are included in this report because of their close proximity to the proposed breakwater. These borings (B-11, B-12, B-13, and B-14) offer the only subsurface information specifically intended for proper and modern design and construction of breakwaters in Hilo Bay. Although these borings are slightly more than 3,200 feet from the proposed breakwater, they offer a good geotechnical basis for correlation with subsurface information from the other data sources. The locations and graphic logs of these borings are presented in Plate G-2 and Plate G-3, respectively.

(3) Probings for Hilo Area Comprehensive Study, 1980

Forty-nine (49) locations within the proposed site were sampled in 1980 using water jetting (wash probing) equipment. The locations of these wash samples are shown on Plate G-2. Table G-1 summarizes the information from these probings. Jet probing was accomplished using a 2" pump and up to 100' of 2" hose attached to a 10' length of 1" pipe. A diver (SCUBA) jetted the pipe vertically into the bottom until some type of refusal was encountered. The refusal was classified as either "hard" indicating firm bottom material was reached, "crunchy" indicating gravel or shells were encountered limiting further penetration, or "seizing" generally caused by a collapse of the sidewalls of the probe hole resulting a halt to penetration. In some instances this latter type of resistance is confused with a lack of sufficient hose to penetrate further often caused by the boat drifting off position. In either instance, the seizing type of refusal suggests that the sediment is possibly thicker than the amount shown.

At stations selected for sampling, a surface sample was obtained before jetting began by the diver in a one quart plastic bag. In some instances a "wash" sample was taken from around the perimeter of the probe hole after the probe was extracted to obtain a composite sample of the subsurface sediments. In general wash samples were not taken where mud was encountered throughout the probing range. Since the subsurface mud is washed up and away from the probe hole in suspension, it does not settle out around the hole; thus wash samples are meaningless under these sediment conditions. In some rubble, the wash sample was taken by the diver by reaching to the bottom of the probe hole (see sample 5-6-W). Samples are designated by their station number with the suffix S or W to denote surface or wash sample and were used to aid in the classification of site materials.

In addition to the jet probings, sediment samples were collected manually at various locations in Hilo Bay for particle size analysis. Table G-2 shows the particle sizes of sediments and Plate G-4 shows the locations. The samples were collected from the surface of the upper sediment layer.

Table G-1 . Summary of Wash Sample Borings

Station Number	Water Depth (Feet)	Probing Depth (Feet)	Type of Refusal	Comments	Sample Number
4-1	41	13	None	Slight crunchy layer at 10 feet	None
4-2	40	13	Seizing	Close to wharf	None
4-3	38	10	Crunchy	Crunchy layer at 7', coral fragments in wash	None
4-4	12	0	Hard	Scattered coral rubble, lava boulders, some sand	4-4-S
5-1	10	4	Hard	Surface is 50% lava cobbles, 50% sand and gravel	5-1-S
5-2	35	4	Crunchy	2 probes	None
5-3	43	13	None	Black mud	None
5-4	42	13	None	Black mud, composit sample from first 3 feet	5-4-C
5-5	15	4	Crunchy	Mud overlying coral rubble	None
5-6	17	3	Crunchy	Mud overlying coral rubble	5-6-S, 5-6-W wash from 4' down
6-1	9	4	Crunchy	Fine white sand	6-1-S
6-2	10	1.5	Crunchy	Coral gravel over rubble, 3 probes	None
6-3	39	13	None	Brown/black mud	6-3-S
6-4	41	13	None	Mud	None
6-5	12	2	Crunchy	Fine sand overlying coral rubble	6-5-S
6-6	13	0	Hard	Coral reef	6-6-S
6-7	10	0	Hard	Dead coral and coral rubble	None
6-8	18	0	Hard	Coral rubble, live coral heads	6-8-S
7-1	11	2	Hard	White sand	None
7-2	11	7	Hard	Fine brown sand	7-2-S
7-3	11	0	Hard	Coral rubble	None
7-4	37	4	Crunchy	Mud with coral head or rock protruding	None
7-5	37	13	None	Brown/black mud	7-5-S
7-6	21	0	Hard	Coral heads on coral rubble	None
7-7	19	0	Hard	Live coral, abundant	7-7-S
7-8	17	0	Hard	Live coral on coral rubble	None
8-1	12	1	Hard	Sand, gravel	8-1-S
8-2	9	6	Hard	Coral rubble over sand and gravel	None
8-3	9	2	Hard	Sand, gravel	8-3-S
8-4	37	13	None	Mud	None
8-5	33	8	Hard	Mud, probe 10' from coral reef	8-5-S
8-6	37	17	Seizing	Mud	8-6-S, 8-6-W
8-7	35	15	Seizing	Mud	None
9-1	10	3	Crunchy	Sand and gravel over rubble	None
9-2	38	14	Hard	Mud	None

Station Number	Water Depth (Feet)	Probing Depth (Feet)	Type of Refusal	Comments	Sample Number
9-3	35	25	Crunchy	Brown mud	9-3-W
9-4	38	17	Hard	Mud	None
9-5	33	0	Hard	Very thin layer of silt over coral reef	None
10	38	7	Crunchy	Rocks protruding from rocks	None
11	40	10	Hard	Brown Mud	11-S
12	42	11	Hard	Mud	None
13	42	13	None	Mud	None
14	42	13	None	Black Mud	14-S
15	43	13	None	Mud	None
16	42	13	None	Mud	None
17	40	7	Crunchy	2 feet of mud over gravel	17-W
18	38	3	Crunchy	Mud with scattered coral formations on surface	None
19	13	3	Crunchy	Same as above	None
20	39	5	Crunchy	Same as above	None

TABLE G-2

HILO BAY SEDIMENTS SIZE DISTRIBUTIONS
(Percent by Weight)

Station	Size (mm) > 4.00	2.00-4.00	1.00-2.00	0.500-1.00	0.250-0.500	1.25-0.25	0.063-0.012	< 0.063
Inner Harbor								
A-1-S	29.8	17.4	14.5	11.2	7.1	5.5	3.6	10.9
A-2-S	0.3	0.4	0.7	1.4	2.1	7.9	10.1	77.2
A-3-S	-	0.1	0.2	0.6	0.6	10.0	6.2	82.3
A-4-S	0.1	0.1	0.3	1.1	1.4	16.6	74.0	6.4
A-5-S	0.2	0.3	0.5	0.8	1.9	5.7	6.4	84.3
A-6-S	0.1	0.1	0.2	0.3	2.5	14.3	11.6	70.9
A-7	8.1	13.2	14.9	10.2	3.4	5.1	17.8	27.3
A-8-S	-	0.1	0.2	3.8	3.0	5.2	6.2	81.5
A-9-S	19.8	19.1	16.7	12.8	7.3	5.3	3.2	15.8
A-10-S	50.9	12.3	17.0	13.2	2.5	1.5	0.8	1.8
A-12-S	12.3	4.8	3.5	2.9	3.5	11.0	14.8	47.3
A-13-W	0.1	0.1	2.7	3.8	2.5	4.8	3.9	82.0
A-16-S	7.2	3.8	5.0	4.1	2.3	4.0	4.7	69.0

Subsurface Conditions

From the preceding data, it was determined that the subsurface materials at the proposed breakwater location consist mainly of loose to slightly consolidated coral rubble (gravel to large cobbles) with various amounts of silt, sand and gravel overlying the rubble. Following the proposed alignment on Plate G-2, the ground surface of the first 400 feet (from the existing breakwater outward) is covered partially by 2 to 4 feet of sediments over a gravel and coral rubble to an unknown depth. The reef flat is exposed in some portions and is covered by scattered lava boulders, live coral heads and coral rubble. Water depths in this area vary from 12 to 15 feet. The bay floor surface for the remaining 1600 feet of breakwater is composed of a shallow reef flat made up of live and dead coral heads, coral rubble and one deep channel that weave through the reef and are covered with a rather thick sediment (mud) layer. The depths of water at this location varies from 10 feet to 35 feet. Standard Penetration Tests (SPT) made in borings for the Hilo Tsunami Protection Project in 1967 suggests that erosion of the reef materials is possible during high wave conditions. These borings show the subsurface reef materials to be a loose to moderately dense mixture of coral limestone reef fragments including sediments ranging in size from silt to cobbles. Additional borings to confirm the preceding subsurface information are required for the development of plans and specifications.

Design Considerations

Proposed Breakwater Toe and Foundation Protection - The subsurface conditions outlined in the preceding paragraph indicates that the foundation materials of the proposed breakwater are erodable during high (storm) wave conditions in certain areas. To prevent erosion of the structure, toe protection will be required in areas subject to wave action. Materials from the existing breakwater (where removed) may be used for the toe protection. In the area of the two sediment (mud) filled channels, stability and settlement of the breakwater (17 feet or more) must also be considered. The remainder of the reef formation will provide an adequate foundation for the proposed breakwater.

Seismicity

Hawaii has the highest density of earthquakes (occurrence of magnitude two and greater earthquakes per unit area) in the United States. Although no active faults have been mapped in the Hilo area, the Army Technical Manual 5-809-10 (Feb 1982) assigns a zone four (4) seismic probability zone for the southeastern half of Hawaii (including Hilo) for design consideration. Damage from a major earthquake with the seismic probability zone 4 is described as great and corresponds to a Z coefficient of 1. The 7.2 magnitude earthquake beneath the Kalapana area on November 29, 1975 was felt in Hilo with an intensity (Modified Mercalli Scale - 1956 version) of VIII.

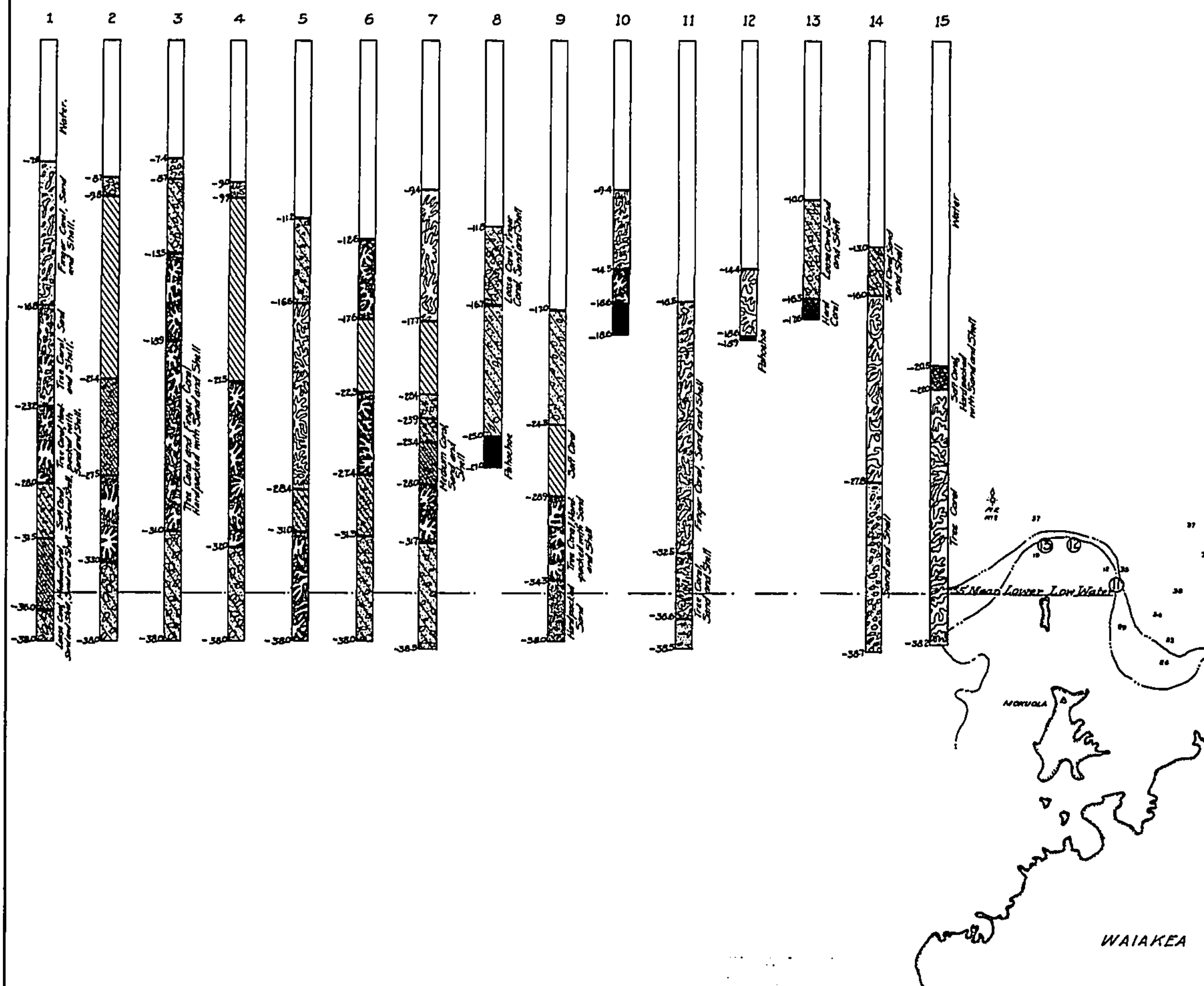
Source of Construction Materials

Revetment stone of suitable quality for the proposed breakwater is available in the project vicinity.

Two commerical quarries operate in the Hilo area are the Glovers quarry and Y and S quarry. Both were used to supply materials for the existing breakwater and are located in the industrial Waiakea District (about one mile south of the Terminal Building at the General Lyman Airfield, less than 5 miles from the project site. The two quarries work the same deposit which was described in detail in Design Memorandum No. 2, Construction of Tsunami Protection and Navigation Improvement Project, Hilo, Hawaii. The rock is a prehistoric member of the Ka'u volcanic series from the Mauna Loa volcano. The bulk specific gravity (S.S.D.) of the basalt from these quarries ranges from approximately 2.50 to 2.80. Recommend use of specific gravity (S.S.D.) of 2.50 for design purposes.

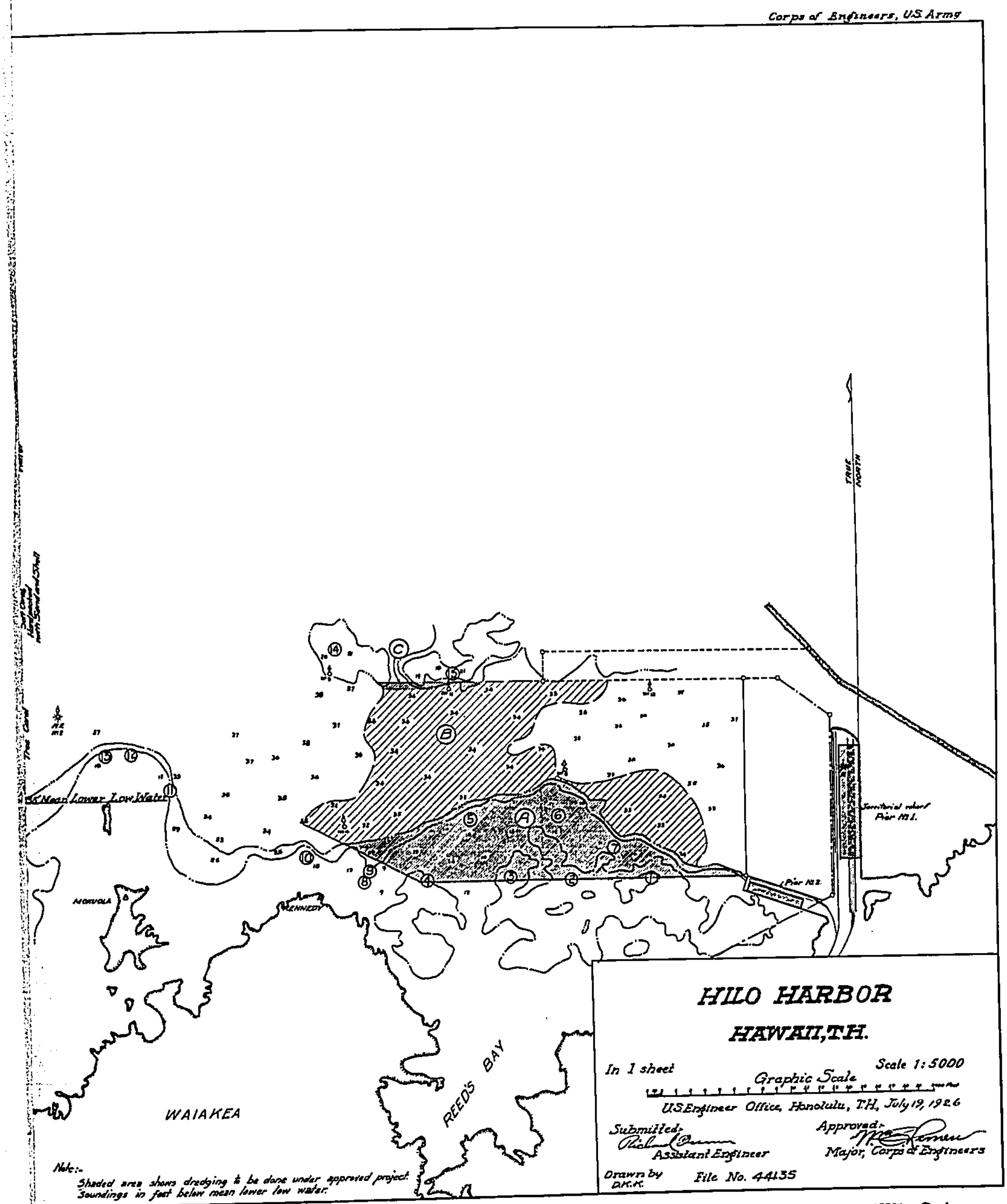
Neither quarry operates to produce armor stone sizes and special arrangements have to be made in advance for large quantities of rock for revetments. Small amounts of large stones are stockpiles in both quarries from time to time.

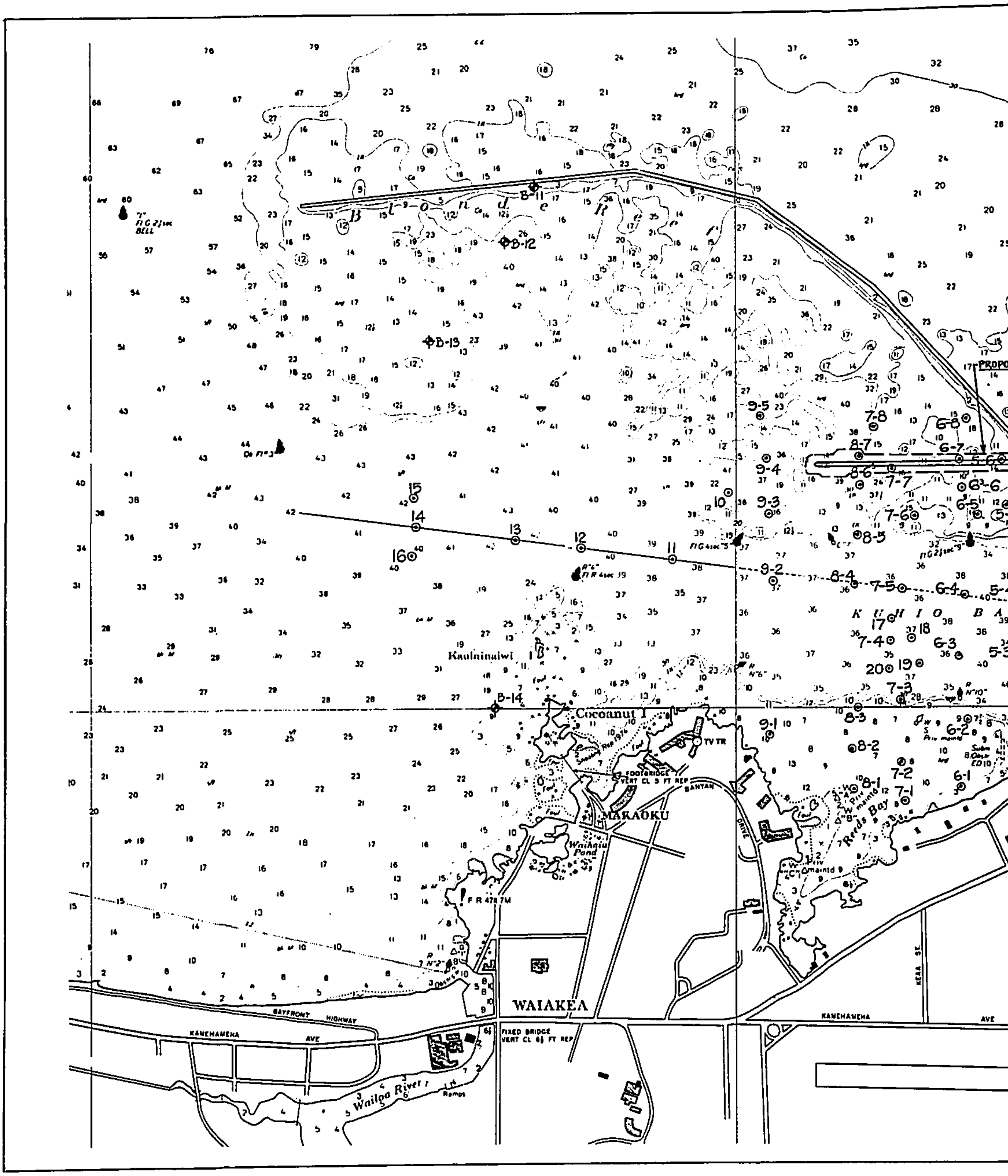
War Department



Wash borings, Kuhio Bay. May 17 to May 29, 1923
By A.H. Hobart

RH 834


Mean Lower Low Water
Territorial wharf Pier No. 1.
Pier No. 2.
TRUE NORTH
MOKUOLA
KENNEDY
WAIAKEA
REED'S BAY
HILO HARBOR
HAWAII, T.H.
In 1 sheet
Scale 1: 5000
Graphic Scale
U.S. Engineer Office, Honolulu, T.H., July 19, 1926
Submitted:
Assistant Engineer
Approved:
Major, Corps of Engineers
Drawn by D.K.K.
File No. 44135
Note:-
Shaded area shows dredging to be done under approved project.
Soundings in feet below mean lower low water.


Blonde Reef
Coconut I
MAKAOKU
WAIAKEA
KUHIO BAY
Reeds Bay
Wailoa River
BAYFRONT HIGHWAY
KAMEHAMEHA AVE
BANYAN DRIVE
FOOTBRIDGE VERT CL 3 FT REP
FIXED BRIDGE VERT CL 6½ FT REP
TV TR
BELL

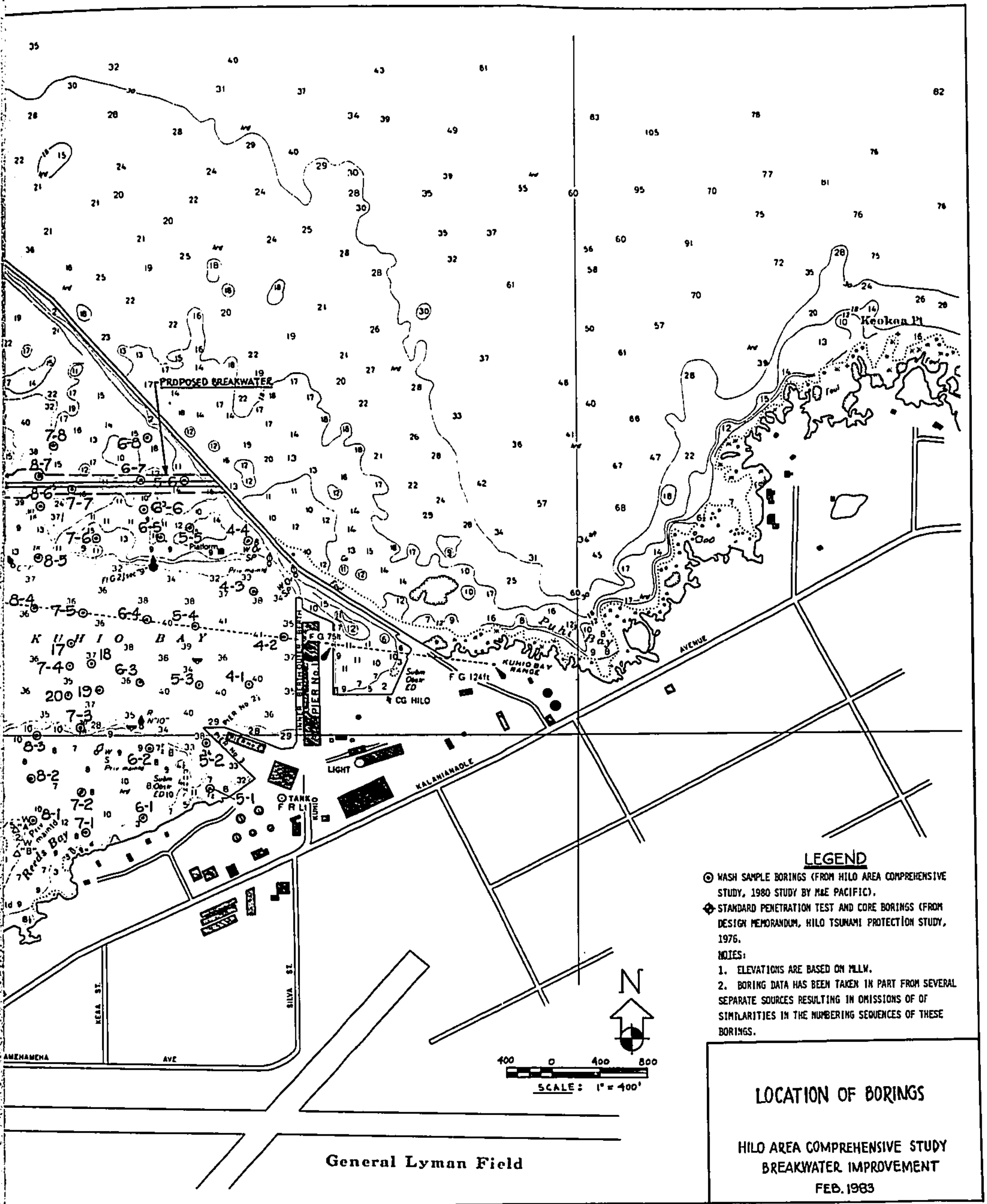
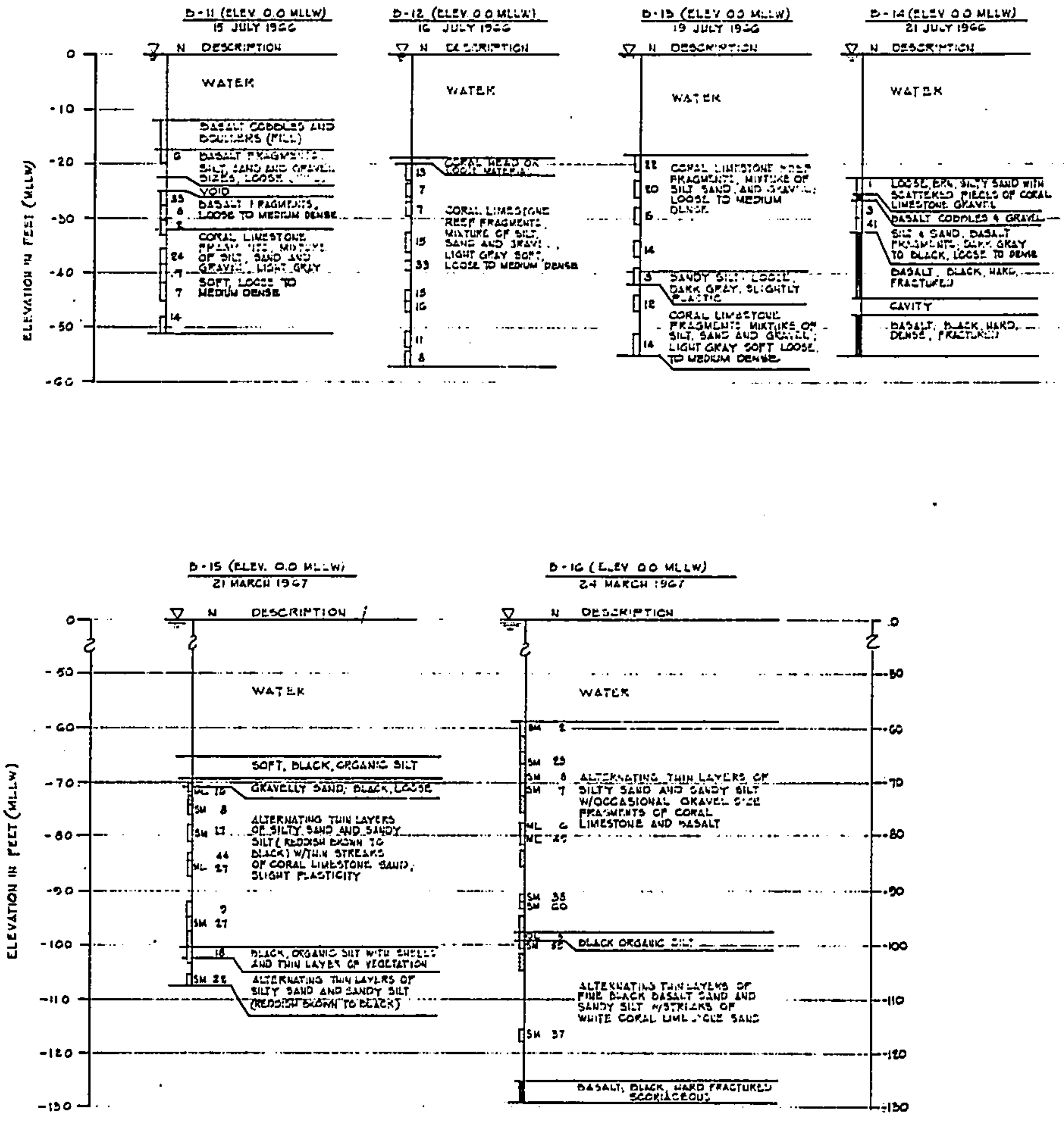
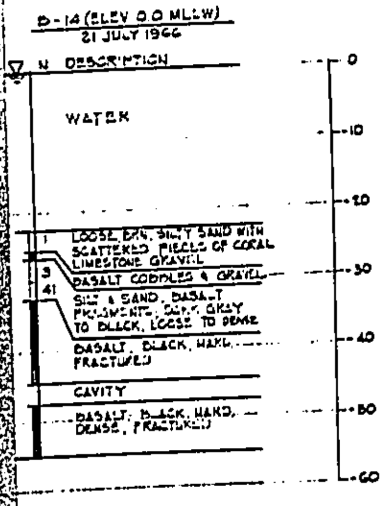

PROPOSED BREAKWATER
KUHIO BAY
PIER No. 1
Keokea Pt
Puhi Bay
Reeds Bay
KUHIO BAY RANGE
CG HILO
LIGHT
TANK
KALANIANAOLE AVENUE
KEAA ST.
SILVA ST.
KAMEHAMEHA AVE
General Lyman Field
N
400 0 400 800
SCALE: 1" = 400'
LEGEND
WASH SAMPLE BORINGS (FROM HILO AREA COMPREHENSIVE STUDY, 1980 STUDY BY M&E PACIFIC).
STANDARD PENETRATION TEST AND CORE BORINGS (FROM DESIGN MEMORANDUM, HILO TSUNAMI PROTECTION STUDY, 1976.
NOTES:
1. ELEVATIONS ARE BASED ON MLLW.
2. BORING DATA HAS BEEN TAKEN IN PART FROM SEVERAL SEPARATE SOURCES RESULTING IN OMISSIONS OF OF SIMILARITIES IN THE NUMBERING SEQUENCES OF THESE BORINGS.
LOCATION OF BORINGS
HILO AREA COMPREHENSIVE STUDY
BREAKWATER IMPROVEMENT
FEB. 1983

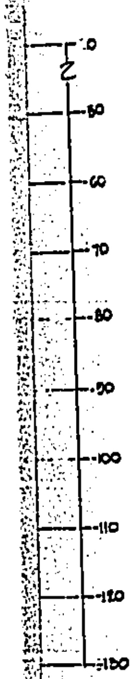
PLATE G-2


B-11 (ELEV 0.0 MLLW)
15 JULY 1966
B-12 (ELEV 0.0 MLLW)
16 JULY 1966
B-13 (ELEV 0.0 MLLW)
19 JULY 1966
B-14 (ELEV 0.0 MLLW)
21 JULY 1966
N
DESCRIPTION
ELEVATION IN FEET (MLLW)
0
-10
-20
-30
-40
-50
-60
WATER
BASALT COBBLES AND BOULDERS (FILL)
VOID
BASALT FRAGMENTS, LOOSE TO MEDIUM DENSE
CORAL LIMESTONE REEF FRAGMENTS, MIXTURE OF SILT, SAND AND GRAVEL, LIGHT GRAY SOFT, LOOSE TO MEDIUM DENSE
SANDY SILT, LOOSE, DARK GRAY, SLIGHTLY PLASTIC
LOOSE, BRN. SILTY SAND WITH SCATTERED PIECES OF CORAL LIMESTONE GRAVEL
BASALT COBBLES & GRAVEL
SILT & SAND, BASALT FRAGMENTS, DARK GRAY TO BLACK, LOOSE TO DENSE
BASALT, BLACK, HARD, FRACTURED
CAVITY
BASALT, BLACK, HARD, DENSE, FRACTURED
B-15 (ELEV. 0.0 MLLW)
21 MARCH 1967
B-16 (ELEV 0.0 MLLW)
24 MARCH 1967
-50
-60
-70
-80
-90
-100
-110
-120
-130
SOFT, BLACK, ORGANIC SILT
GRAVELLY SAND, BLACK, LOOSE
ALTERNATING THIN LAYERS OF SILTY SAND AND SANDY SILT (REDDISH BROWN TO BLACK) W/THIN STREAKS OF CORAL LIMESTONE SAND, SLIGHT PLASTICITY
BLACK, ORGANIC SILT WITH SHELLS AND THIN LAYER OF VEGETATION
ALTERNATING THIN LAYERS OF SILTY SAND AND SANDY SILT (REDDISH BROWN TO BLACK)
ALTERNATING THIN LAYERS OF SILTY SAND AND SANDY SILT W/OCCASIONAL GRAVEL SIZE FRAGMENTS OF CORAL LIMESTONE AND BASALT
BLACK ORGANIC SILT
ALTERNATING THIN LAYERS OF FINE BLACK BASALT SAND AND SANDY SILT W/STREAKS OF WHITE CORAL LIMESTONE SAND
BASALT, BLACK, HARD FRACTURED SCORIACEOUS



NOTES TO BORING LOGS

1. SOIL CLASSIFICATIONS SHOWN ON THE BORING LOGS ARE IN ACCORDANCE WITH MIL STD 619A
2. DATE INDICATED ABOVE BORING LOG IS DATE BORING WAS COMPLETED
3. ELEVATIONS ARE BASED ON MLLW
4. N - RESISTANCE TO PENETRATION OF STANDARD 2" OD. SAMPLING SPOON DRIVEN 1 FOOT WITH 140 LB. WEIGHT FALLING 30 INCHES
5. ▽ - GROUNDWATER OR MLLW LEVEL
6. ▯ - SPLIT SPOON SAMPLE
7. ▯ - SHELBY TUBE SAMPLE
8. ▮ - NX CORE SAMPLE
9. SM - SILTY SAND, SAND - SILT MIXTURES
10. ML - INORGANIC SILTS AND VERY FINE SANDS, SILTY OR CLAYEY FINE SAND OR CLAYEY SILTS WITH SLIGHT PLASTICITY
11. OL - ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
12. SEE PLATE D-8 FOR LOCATION OF BORINGS
13. BORINGS B-15 AND B-16 ARE NOT WITHIN CLOSE PROXIMITY OF THE PROPOSED BREAKWATER AND ARE NOT SHOWN ON PLATE D-8 "LOCATION OF BORINGS"



U. S. ARMY ENGINEER DISTRICT, HONOLULU
CORPS OF ENGINEERS
HONOLULU, HAWAII

HILO AREA COMPREHENSIVE STUDY
BREAKWATER IMPROVEMENTS

BORING LOGS

DATE FEB 1983

PLATE G-3

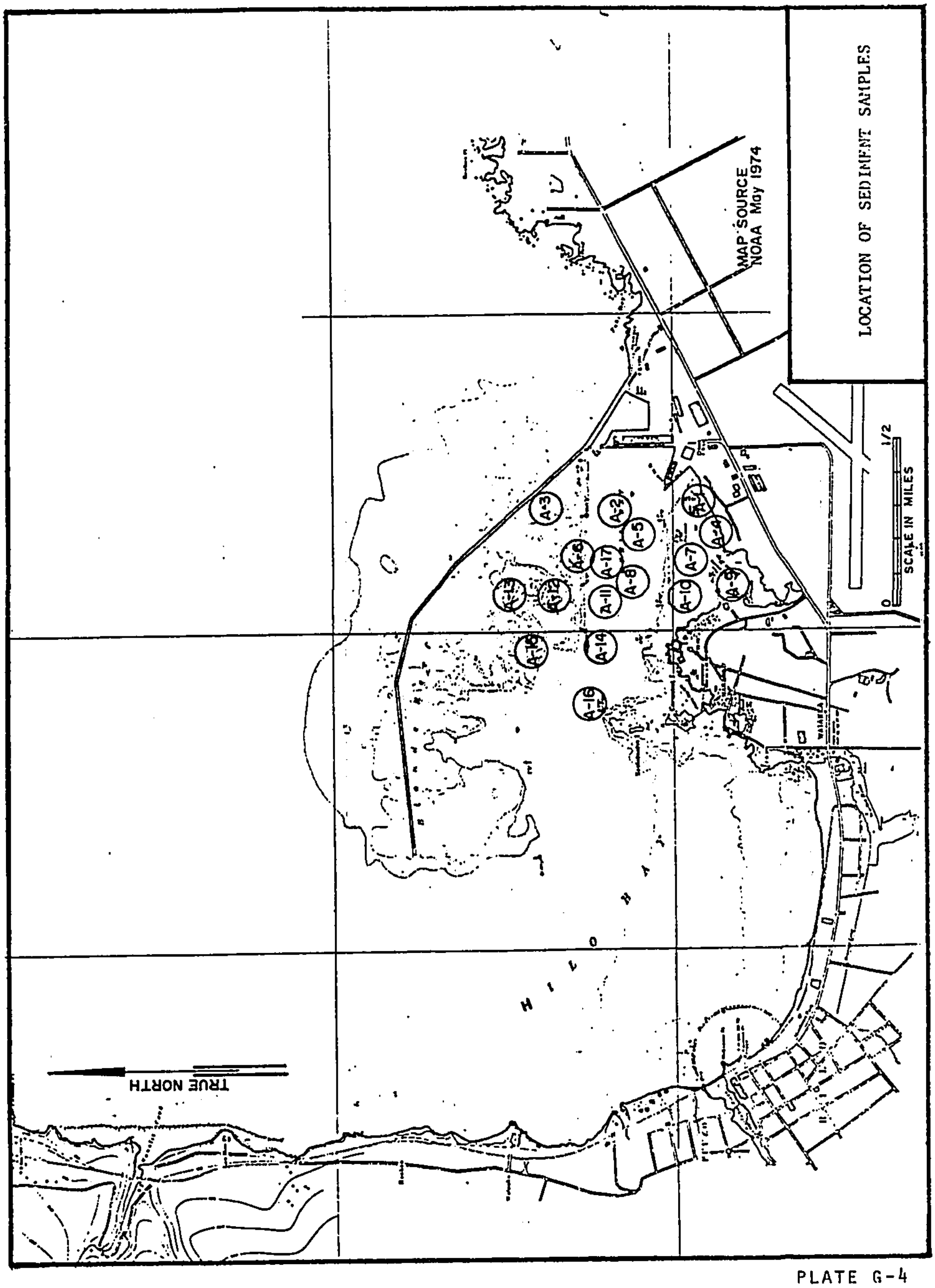

LOCATION OF SEDIMENT SAMPLES
MAP SOURCE
NOAA May 1974
SCALE IN MILES
0
1/2
TRUE NORTH
HILO BAY
A-1
A-2
A-3
A-4
A-5
A-6
A-7
A-8
A-9
A-10
A-11
A-12
A-13
A-14
A-15
A-16
A-17

PLATE G-4

SUPPORTING DOCUMENTATION

ECONOMICS

HILO HARBOR, HAWAII
PROPOSED BREAKWATER MODIFICATION

ECONOMICS

GENERAL

The existing deep-draft harbor at Hilo is an authorized project which includes a rubblemound breakwater 10,080 feet long; an entrance channel 35 feet deep; and a turning basin 1,400 feet wide, 2,300 feet long, and 35 feet deep. The project was authorized in the River and Harbor Acts of 2 March 1907, 25 July 1912, and 3 March 1925. The project was completed in July 1930.

PROBLEMS AND NEEDS

The Corps of Engineers is responsible for the maintenance of the 10,080 foot rubblemound breakwater. A 900-foot section directly seaward of Pier 1 was reinforced in 1981 with tribars and covered with reinforced concrete ribs at a cost of about $2 million. Additional work is expected to be done during the next few years to repair the entire breakwater. The breakwater is over 50 years old and does not meet current design criteria.

The existing breakwater design restricts water circulation in the bay and reduces flushing by fresh ocean water. Circulation improvements are essential if the bay's water quality is to be upgraded.

A new breakwater design has been proposed to replace the aging breakwater. The new design would provide the same protection to Hilo's deep draft port facilities while significantly reducing annual maintenance and storm repair costs. The modified breakwater would also substantially improve circulation and enhance water quality in Hilo Bay. This plan which would best address Hilo Bay's needs for harbor protection and improved water quality is partial removal of the armor stone and core of the outer 7,000 feet of existing breakwater. A 2,000-foot inner breakwater would be constructed projecting inward from the remaining 2,500 feet of the existing breakwater.

METHODOLOGY

In evaluating the economic feasibility of the proposed breakwater modification, the tangible benefits were determined by (a) considering current port operations and needs, and (b) analyzing the expected future conditions with and without the project. Data used in the evaluation of benefits were obtained from field investigations, interviews with public and private interests and from Federal, State, and local published reports, newspaper articles, and periodicals. The base year of the proposed project was assumed to be 1985, the interest rate used is 7-7/8 percent, and economic life is 50 years.

The development of benefits follows standard Corps of Engineers practice. The value of all goods and services used in the project was estimated at 1982 prices.

BENEFITS

The primary measurable monetary benefits of the proposed new breakwater modification plan are tsunami and storm repair savings and savings from expected new work. The estimated monetary values are based on 1982 price levels and 1985 economic conditions. The projected 1985 economic condition was selected for use in the study since this is the year the recommended plan is expected to be operational.

RESOURCES AND ECONOMY

GENERAL

Hawaii is a prosperous state with a growing economy. The gross state product in 1979 amounted to $10 billion, or almost 6 times the 1960 total. The three largest contributors to the state economy are tourism ($3.0 billion), defense expenditures ($1.3 billion), sugar production ($594 million), and pineapple production ($223 million). The most rapid growth in the past decade has been in the tourist industry. Visitor expenditures have increased over 400 percent in the ten years from 1969 to 1979. Visitor spending in 1980 resulted in tax revenues of $323 million and generated 117,000 jobs.

Hawaii County experienced a population increase of 50 percent from 1960 to 1980, nearly equalling the state's overall increase of 52 percent for the same period. The resident population of the Hilo area (Puna, North Hilo and South Hilo districts) increased by 43 percent from 39,076 in 1960 to 55,708 in 1980. Sixty percent of the population on the island is centered in the Hilo area.

The basic elements of the economy of Hawaii County are tourism, agriculture and fishing, manufacturing, and scientific research with tourism being the number one industry. Visitor expenditures for Hawaii County grew from $50 million in 1969 to $172 million in 1979. While Hilo is not noted as a destination area, its role as a gateway to and from the state suggests a continued active role in the visitor industry. As the urban, commercial, and government center for the county, Hilo has a stronger orientation toward transportation, communications and utilities, trade, services, and government. It is expected that Hilo will contine to be the major urban center on the island. The following tables summarize the demographic, general social, and economic characteristices of the county.

Table 1
RESIDENT POPULATION OF HAWAII COUNTY AND DISTRICTS:
1960 TO 1980

	1960	1970	1980
The State	632,772	769,913	965,000
Hawaii	61,332	63,468	92,053
Puna	5,030	5,154	11,751
South Hilo	31,553	33,915	42,278
North Hilo	2,493	1,881	1,679
Hamakua	5,221	4,648	5,128
North Kohala	3,386	3,326	3,249
South Kohala	1,538	2,310	4,607
North Kona	4,451	4,832	13,748
South Kona	4,292	4,004	5,914
Ka'u	3,368	3,398	3,699
Median Years of School Completed1/	8.6	11.4	NA

1/ 25 years old and over.

Source: U.S. Bureau of the Census, U.S. Census of Population: 1970, PC(1)-A13, table 10, and advance counts from the 1980 Census of Population.

Table 2

INCOME, LABOR FORCE, AND EMPLOYMENT

	1960	1970	1980
Personal Income ($Millions)	100	241	650 2/
Per Capita Income ($)	1,630	3,785	7,760 2/
Civilian Labor Force	22,270 1/	28,300	35,450
Civilian Employment	21,520 1/	27,050	33,050
Unemployment (%)	3.4	4.4	6.7
Subcount by Industry			
Total Job (Non-agriculture)	16,040	28,870	8,400
Construction	320 1/	1,500	1,650
Manufacturing	3,300 1/	2,960	2,750
Transportation, Communication, and Utilities	970 1/	1,380	1,900
Trade	3,100 1/	5,010	7,000
Finance, Insurance and Real Estate	250 1/	900	1,100
Services	1,640 1/	3,370	7,450
Government	3,050 1/	4,370	6,550
Agriculture	2,910 1/	3,610	3,250

1/ Hawaii State Dept of Labor and Industrial Relations.

2/ 1979 Estimate.

Source: State of Hawaii Data Book 1981; County of Hawaii Data Book 1980 and 1979, Department of Research and Development.

Table 3

TOURISM HAWAII COUNTY

	1960	1970	1980
Visitor Arrivals	72,300	445,401	761,000
Visitor Expenditures ($ Millions)	5.6	53.4	172[1/]
Hotel Room Inventory	558	3,092	6,260
Occupancy Rate ($)	NA	68.3	52.7

1/ 1979 Estimate

Source: County of Hawaii Data Book 1981, Department of Research and Development. The State of Hawaii Data Book, 1962, Dept of Planning and Economic Development.

AGRICULTURE

Agriculture is not the predominant source of income for the State it once was, but it still ranks 3rd behind only tourism and military expenditures. Tourism contributed an estimated $3 billion to the Hawaiian economy while Federal defense expenditures accounted for $1.34 billion in 1980. Sales from agricultural products totaled $1.013 billion in the same year. Sugar accounted for over 62 percent of this with $631 million in sales, pineapple 21 percent or $213 million. Diversified agriculture representing the remainder accounted for 17 percent or $169 million.

Table 4. Value of Agricultural Sales
(1,000 dollars)

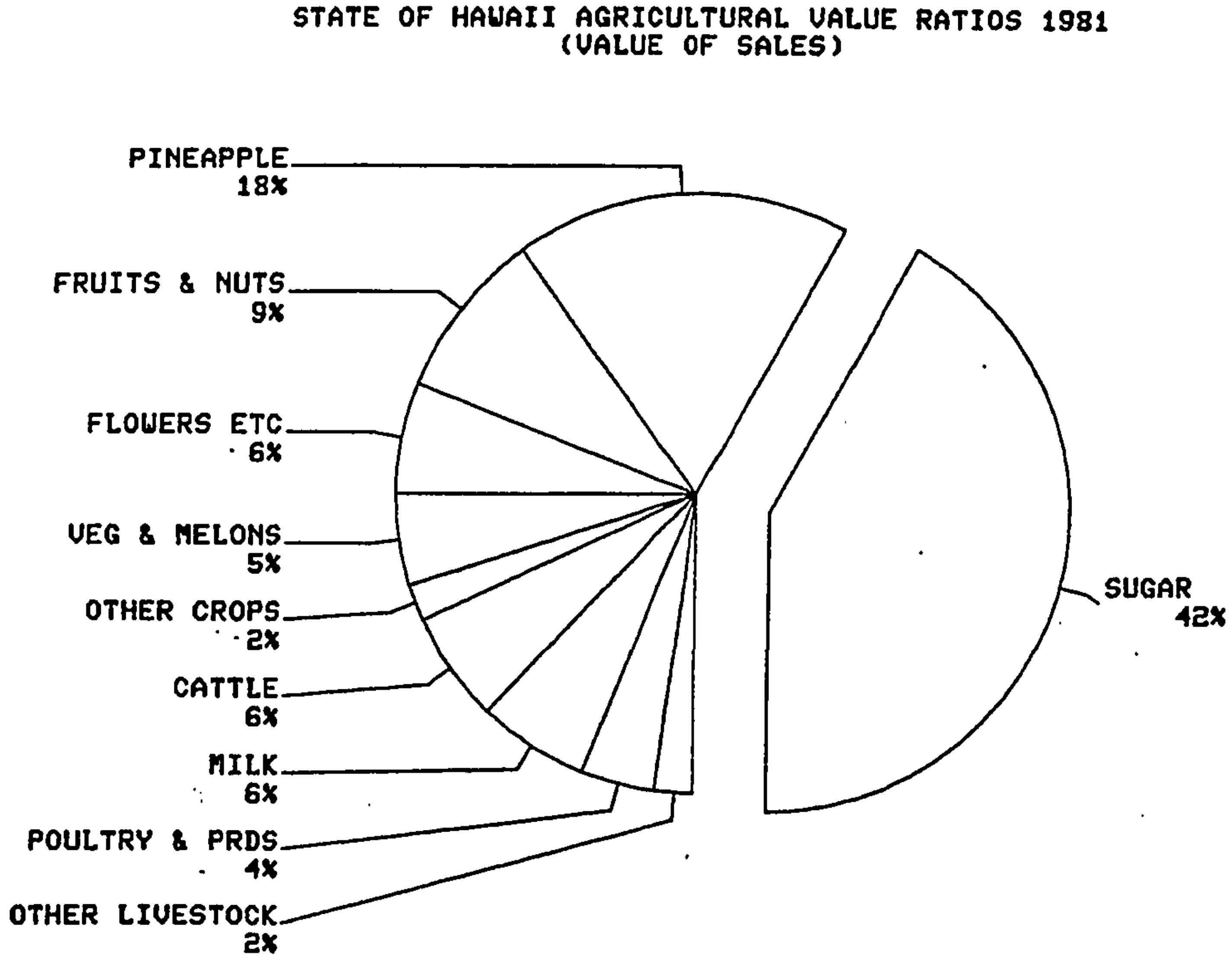
Year	Sugar	Pineapple	Diversified Agriculture 1/	Total Crops and Livestock
1977	144,200	62,249	53,715	325,182
1978	182,700	63,090	62,308	380,655
1979	217,600	69,409	75,780	441,253
1980	385,100	76,596	91,181	634,101
1981	207,400	89,745	104,103	489,435

1/ Includes: Vegetables, melons, fruits (excluding pineapple), coffee (parchment), macadamia nuts, taro, miscellaneous crops, flowers and nursery products.

Source: Statistics of Hawaiian Agriculture 1981, Hawaii Department of Agriculture and U.S. Department of Agriculture.

As Table 4 clearly shows the significant decrease in agricultural sales in 1981 was caused entirely by the sugar industry. The low price of sugar in 1981 caused the farm value of agriculture to plunge 23 percent from a record high the previous year. However, the value of the sugar industry to the State is still paramount as evidenced graphically by Figure 1.

Figure H-1.



CARGO TRENDS AND PROJECTIONS

The island of Hawaii is served by two major commercial deep-draft ports: Hilo Harbor, located on the northeast coast and Kawaihae Harbor on the west coast. Hilo Harbor, which fronts the city of Hilo, was constructed in 1930 and is the second largest deep-draft port in the State. Hilo is also the second largest city in the State of Hawaii and is the center of economic activity on the island. Within the last decade, an average annual cargo of more than 1,000,000 short tons passed through Hilo Harbor. Principal imports at Hilo include general cargo and petroleum products. Principal exports include sugar and molasses. Kawaihae Deep-Draft Harbor, constructed in 1957, is approximately 85 nautical miles northeast of Hilo. Kawaihae Harbor provides major services to sugar plantations on the western half of the island. In 1978, the harbor handled over 500,000 short tons of cargo of which over one-third was sugar and molasses. General cargo shipments received at Kawaihae Harbor cover a broad, even spectrum with no one import dominating the statistics. Sugar and molasses are the principal export items from Kawaihae. Bulk sugar and molasses are transshipped to the mainland for processing. Table 5 gives a breakdown of the total cargo traffic through both harbors from 1966 to 1978.

Table 5. Total Cargo Traffic to Hilo and Kawaihae Harbor 1/ Hawaii County (1966-1978), Short Tons

Year	Hilo	Kawaihae
1966	835,029	266,894
1967	882,535	265,625
1968	991,111	342,614
1969	990,476	317,415
1970	1,141,163	329,425
1971	1,064,384	355,546
1972	1,108,067	303,116
1973	1,041,647	385,850
1974	928,619	291,036
1975	1,053,879	279,687
1976	995,544	263,562
1977	1,013,430	318,197
1978	1,272,734	502,451

1/ Waterborne Commerce of the United States, Department of the Army, Corps of Engineers.

Petroleum

Total energy consumption in the State of Hawaii increased at an average annual rate of 9 percent from 1934 to 1974, compared with a 2 percent annual growth rate in population. From 1975 to 1978, conservation in energy consumption resulted in a somewhat slower increase of about 3 percent a year compared with a 2.4 percent growth rate in population. Petroleum imports on the Big Island of Hawaii increased from 136,100 short tons in 1965 to 225,174 short tons in 1978, representing a 4.0 percent annual rate of growth. The bulk of the petroleum imported to the Big Island is transshipped by barge from Honolulu. During this 13-year period, the population of Hawaii County grew at an annual rate of 2.1 percent for a 31 percent increase. The growth rate of per capita energy consumption for this period was 2.3 percent. Total potential petroleum shipments to Hawaii County were projected (Table 6), based on the future per capita consumption growth rate used in the petroleum demand study conducted by Tudor Engineering Co. and II-F population projects available from the Department of Planning and Economic Development (DPED).

Table 6. Petroleum Energy Equivalent Consumption Projections for Hawaii County

Year	Total Projected Shipments to Hawaii County (Short Tons)	Population 2/	Energy Projections in Equivalent Petroleum Tons Per Capita 4/
1978	225,174 1/	80,900 3/	2.78 5/
1980	263,709	92,053 6/	2.86
1985	292,600	95,200	3.08
1990	347,600	105,000	3.31
1995			3.57
2000	461,300	123,300	3.75
2010	571,300	138,000	4.14
2020	674,300	155,000	4.35
2025			4.46
2030	776,000	174,000	4.46
2035	820,100	184,000	4.46

1/ Actual - from Waterborne Commerce of the U.S.
2/ From II-F projections, DPED (modified to include 1980 census estimate).
3/ Actual - Hawaii Data Book (1979).
4/ Based on Tudor Engineering Study, per capita energy consumption will increase at the following rates:

1975-1995	1.5 percent per year
1995-2010	1.0 percent per year
2010-2025	0.5 percent per year
2025-2035	No increase

5/ Actual - 225,174 - 80,900 = 2.78.
6/ 1980 Census.

Future petroleum imports to Hilo Harbor are based on this projection of total petroleum shipments to Hawaii County, historical records, and population estimates. Historical trends indicate that over a 13-year period from 1966-1978 (Table 7), an average of 92 percent of the total shipments to Hawaii County were handled at Hilo Harbor. Therefore, taking 92 percent of the total projected total shipments to Hawaii County gives us an estimate of the total shipments to Hilo Harbor (Table 8).

Table 7. Petroleum Inshipments to Hawaii County (1965-1978)

Year	Total Inshipments To Hilo (Short Tons)	% of Total	Total Inshipments To Kawaihae (Short Tons)	% of Total	Total Inshipments To Hawaii County (Short Tons)
1965	145,400	100			145,400
1966	174,847	94	11,433	6	186,280
1967	157,074	90	16,698	10	173,772
1968	209,245	90	23,204	10	232,449
1969	280,085	92	23,162	8	303,247
1970	337,166	90	38,879	10	376,045
1971	285,996	88	38,541	12	324,537
1972	308,398	89	38,511	11	346,909
1973	240,226	92	19,756	8	259,982
1974	235,625	93	18,735	7	254,360
1975	243,042	94	14,331	6	257,373
1976	234,305	95	12,071	5	246,376
1977	236,115	95	11,521	5	247,636
1978	209,623	93	15,551	7	225,174
		92%		8%	

Table 8. Future Petroleum Inshipments To Hilo Harbor Short Tons

Year	Total Inshipments 1/ To Hawaii County	Total Inshipments 2/ To Hilo Harbor
1980	263,709	242,600
1985	292,600	269,200
1990	347,600	319,800
2000	461,300	424,400
2010	571,300	525,600
2020	674,300	620,400
2030	776,000	713,900
2035	820,100	754,400

1/ From Table 6.
2/ Based on 92 percent of total inshipments to Hawaii County.

The County of Hawaii is making efforts to reduce its reliance on imported energy which is currently 62 percent of the total island energy consumption. Studies and experiments on alternative energy sources, including biomass, geothermal, and oceanthermal, are being conducted to determine their feasibility. It is conceivable that the majority or possibly all of the future electric power could be generated from these alternate energy sources.

The reduction in petroleum consumption could be significant since electrical power generation consumes approximately 33 percent of the island petroleum demand. The remaining petroleum is used for land, water, and air transportation.

General Cargo

Major import items handled through Hilo Harbor include fabricated metal products, general commodities, and construction materials. Cargo inshipments to the Big Island increased from 246,582 short tons in 1966 to 720,359 short tons in 1978. During this same period, cargo inshipments to Hilo increased from 212,538 short tons to 579,230 short tons, representing roughly 85 percent of all general cargo traffic to Hawaii County. In 1978, outshipments at Hilo Harbor remained relatively unchanged from 1966, with sugar and molasses accounting for about 78 percent of all export items.

Projections of inshipments of general cargo for consumption on the Big Island have been constructed by analyzing historical trends and relationships. Multiple regression analysis was performed on 24 years of data for the Hawaii State ports in order to relate the dependent variable of cargo inshipments to an array of independent variables. (Inter-Island Navigation Facilities Demand by Pacific Analysis Corporation 1976) (Proceedings Twenty-first Annual Meeting Transportation Research Forum 1980, page 298-310.) Among the dozens of models developed, the following model works equally well for each of the major islands in the State and is considered to be the most reasonable and reliable, meeting the criteria of (1) good statistical fit with historical data, (2) incorporation of independent variables that have a logical relationship to the dependent variable and (3) independent variables that can be reasonably projected for the next 50 years.

C = 28.6 (PURPWR) 0.5 + 1382 (TOUR) 0.5 - 116,188
(R-SQ .9/57; STD E of E 6701/; F RATIO 1219) ANOVA

Where C = inshipment tonnage of general cargo to Hawaii County
PURPWR = resident population x per capita income at 1967 price levels
TOUR = hotel rooms x occupancy rate

Table 9 shows the estimated general cargo inshipment tonnages using this model and the input data, including projections of population, per capita income and tourism.

Table 9. Projections of Waterborne General Cargo Inshipments
Hawaii County

Year	Population	Per Capita Income ($)	Purchasing Power $(10^3)$$	Tourism	Inshipment Tonnage (10^3)
1985	95,000	4,321	410,000	7,067	579
1990	105,000	4,824	507,000	9,778	664
2000	123,000	5,655	696,000	14,125	802
2010	138,000	6,611	912,000	14,125	912
2020	155,000	7,819	1,212,000	14,125	1,044
2030	174,000	9,253	1,610,000	14,125	1,196
2035	184,000	10,064	1,852,000	14,125	1,279

Future inshipments of general cargo to Hilo Harbor were based on historical trends and a projection of total general cargo inshipments to Hawaii County. During the 13-year period from 1966 to 1978, an average of 85 percent of the total inshipments to the Big Island were handled at Hilo Harbor (see Table 10). Therefore, taking 85 percent of the projected total shipments to Hawaii County will give us the projected shipments to Hilo Harbor (Table 11).

Table 10. General Cargo Inshipments to Hawaii County (1965-1978)

Year	Total Inshipments To Hilo (Short Tons)	% of Total	Total Inshipments To Kawaihae (Short Tons)	% of Total	Total Inshipments To Hawaii County (Short Tons)
1965	209,293	100	-	-	209,293
1966	212,538	86	34,044	14	246,582
1967	193,664	79	36,254	21	229,918
1968	204,905	83	42,112	17	247,017
1969	247,873	84	48,995	16	296,868
1970	324,655	83	64,664	17	389,319
1971	324,687	87	48,241	13	372,928
1972	375,996	85	64,315	15	440,311
1973	328,850	86	55,460	14	384,310
1974	264,116	85	47,136	15	311,252
1975	362,607	89	45,697	11	408,304
1976	336,816	89	42,069	11	378,885
1977	335,365	85	57,272	15	392,637
1978	579,230	80	141,129 1/	20	720,359
		85%		15%	

1/ The significant jump in total inshipments to Kawaihae in 1978 is almost entirely the result of the increase in shipments of motor vehicles, parts, and equipment. In 1977, the port received 9,203 short tons of these commodities. In 1978, total receipts were 87,038 short tons for an increase of 77,835 short tons. In Hilo Harbor, the increase in inshipments was relatively evenly distributed among all commodities.

Table 11. Future General Cargo Inshipments to Hilo Harbor (Short Tons)

Year	Tons
1985	492,500
1990	564,500
2000	682,000
2010	775,100
2020	887,200
2030	1,016,300
2035	1,087,000

Manganese Nodules

The economic impact of potential manganese nodule mining operations could be significant for the State. Because of the proximity of the State to the belt of high-grade nodules, development of a manganese nodule industry appears attractive for Hawaii. If tests currently underway prove successful, mining of deep-sea manganese nodules southeast of Hawaii could begin within a few years. Initial construction of a processing plant and associated infrastructure would require a capital investment of $521 million. An additional $20 to $24 million would be needed for construction of a power-generating plant. It has been estimated that during the three-year construction phase, the Gross State Product would increase by about $202 million annually and an additional 6,000 new jobs would be created. About 5,000 of these jobs would be available in Hawaii County with 3,000 in the construction industry.

Preliminary feasibility studies have investigated the Puna District on the Big Island as a potential site for the manganese processing facilities. A major requirement for the processing plant will be the availability of energy resources. Scientists have estimated that the Puna area has enough geothermal resources to produce from 400 to 500 megawatts of power.

Approximately 3 million wet (2.25 million dry) metric tons of nodules are expected to be mined and processed annually. This new industry would increase the Gross State Product by $335 million and add an additional 2,400 jobs to the State labor force.

The impact of the manganese nodule industry on Hilo Harbor could be significant. Transport of nodules from the primary mining areas would be by a tug and barge system because of the relatively short distance involved. Based on existing harbor and channel depths of 35 feet at Hilo Harbor, draft restrictions limit the maximum size of a bulk carrier (barge) to about 35,000 DWT. At the Port of Hilo, special storage facilities requiring about 10 acres will be needed to receive nodule shipments. The ocean transportation system will consist of a fleet of four barges with individual capacities of 35,000 DWT. In order to transport the projected 3 million metric tons of manganese nodules, each barge will be required to make 24 trips a year.

FLEET COMPOSITION

Existing Fleet Characteristics

The growth of waterborne commerce within the State of Hawaii has been in an uptrend over the past few years. With a growing population, increased demands for food, fuel, and other major commodities resulted in an upturn in inter-island transportation. Barges, containerships, and tankers provide the major modes of travel for cargo destined for Hilo Harbor.

Barge - General Cargo

Barge traffic through Hilo Harbor during 1978 represented approximately 60 percent of all incoming vessel traffic. (The names of individual shipping companies and vessels will not be used in this appendix to avoid any possible disclosure of confidential information. Company and vessel or barge names have been replaced when necessary with a number and letter.) There are seven companies that operate barges; the largest currently brings in general cargo to Hilo Port. Recent trends in shipping have tended towards containerized cargo, and in 1979, 59,141 revenue tons or 26 percent of all general cargo brought in by one company was containerized. The predominant size container used is 20 feet. The barges used have a rated capacity ranging from 2,000 to 3,700 tons and a maximum draft between 6 and 7 feet. Existing service to Hilo is provided three times a week.

A second company, with main headquarters in the Pacific Northwest, imports lumber and wood products to the State. Its existing operation at Hilo port consists of movement by tug and tandem barge. These barges, which call on Hilo Harbor once a month, have rated capacities from 3,600 - 5,400 tons and fully loaded draft of 14 feet.

A third company provides most of the fertilizer and chemical products consumed in Hawaii County. Tug and barge operations are being utilized to deliver dry bulk shipments of fertilizer as well as other chemical products. Existing service to Hilo is provided 6 times a year by a 15,500-ton capacity barge.

A fourth company, with its own barge operation, calls on Hilo Harbor approximately 18 times a year with a full load of cement for the local construction industry.

Barge - Petroleum

Petroleum and petroleum products are supplied by three major producers. Transshipment of these products is done principally by tug and barge operations. The largest supplier of petroleum brought in approximately 958,000 barrels in 1979, accounting for over 50 percent of the total imports to Hilo. The barge used had a rated capacity of 60,000 barrels and a fully loaded draft of 21 feet. During the past year, this barge made a total of 24 trips or an average of 1 trip about every 2 weeks.

Two other barges are also used to transport petroleum to Hilo Harbor. One of the barges, with a rated capacity of 30,000 barrels, averaged 10,000 barrels per trip in 1979. The barge made a total of 24 trips to Hilo Harbor last year.

Petroleum Tankers

Sister ships owned and operated by another major oil company are currently the only petroleum tankers calling at Hilo Harbor. Both vessels are 661 feet in length, 90 feet in breadth and have an international summer draft of just under 36 feet. Although the tankers have a maximum draft of almost 36 feet, company officials indicated the tankers have not encountered any major navigational problems at Hilo. Since most of the shipment to Hawaii from the mainland is jet fuel, major deliveries are unloaded to Honolulu Harbor before the remaining load is delivered at Kahului Harbor on Maui and Hilo Harbor. The maximum draft of these tankers is never reached because of sharply reduced loads when entering Hilo Harbor. During the past year, the capacity of these ships did not exceed half of their maximum, 35,000 DWT.

Dry Bulk Carriers

Dry bulk carriers play a major role in Hawaii's export and interisland transportation system. These ships have been used to export bulk sugar as well as servicing Hilo port with general bulk cargo. The existing fleet, used for exporting sugar and molasses, consists of four vessels, the largest with a rated capacity of 31,500 DWT. Other vessels are used intermittently when the need arises. Two vessels will soon be phased out of serving Hilo. The composition of the dry bulk carriers will make further changes with the introduction of the new Integrated Tug and Barge (ITB) scheduled to be put into service in late 1982 (see Future Fleet Characteristics).

Containerships

Major container port operations at Pier 1 involve the loading and unloading of roll-on/roll-off (RO/RO) and load-on/load-Off (LO/LO) vessels. The existing fleet calling at Hilo Harbor consists of two vessels. One vessel (LO/LO) has a capacity of 187 24-foot containers and calls on Hilo Harbor once a week. The other vessel (RO/RO) has a capacity of 293 40-foot containers and an additional 160 autos and calls on Hilo about every other week. The RO/RO vessel is capable of unloading 26 containers and 40 autos per hour. The LO/LO vessel unloads 20 containers per hour. A third vessel (RO/RO) has been lengthened to handle lift-on, lift-off containers. The ship will get an additional 126-1/2-foot midbody section, increasing its total length of 826-1/2 feet. The increased length enables the vessel to handle 1,046 24-foot equivalents of trailer and container units compared with its previous capacity of 434 equivalents. The ship is not yet scheduled to serve Hilo Harbor, but could possibly be used to complement the existing fleet in the future.

Interisland Cruise Ships

Congressional authority was granted for a passenger cruise ship to serve Hawaii, and interisland cruises began on June 21, 1980. The 750-passenger, 20,300-ton vessel sails from Honolulu, Oahu, and makes full day calls at Hilo and Kona on the Big Island, Kahului on Maui, and Nawiliwili, Kauai. The ship is 682 feet long and draws a maximum loaded draft of 23 feet. A second passenger vessel of similar dimensions has recently been added by the owners of the other ship.

A summary of the existing vessel fleet is shown in Table 12.

Table 12. Existing Vessel Fleet 1/2/

Company Vessel	Type	DWT	Loaded Draft (Feet)	Length (Feet)
Company No. 1				
Vessels A	Containership	4,400	18' 4"	338'
B	Containership	14,000	28' 1"	700'
C	Bulk Carrier	18,500	32'	630'
D	Bulk Carrier	18,500	32'	630'
E	Bulk Carrier	24,000	33' 8"	595'
F	Bulk Carrier	31,500	33' 10"	641'
G	Bulk Carrier	24,400	32' 6"	626'
H	Bulk Carrier	24,400	32' 6"	626'
Company No. 2				
Vessels I	Tanker	35,000	35' 8"	661'
J	Tanker	35,000	35' 8"	661'
Company No. 3				
Vessel K	Tanker	28,900	29' 5"	492'
Company No. 4				
Vessels L	Passenger Ship	750 passengers	23'	682'
M	Passenger Ship	750 passengers	23'	682'

1/ Companies and vessel names have been replaced with a number and letter to avoid disclosure of confidential information. This policy will be followed where necessary throughout the remainder of this section of the report.
2/ Does not include barge traffic. There are seven companies using barges to Hilo.

FUTURE FLEET CHARACTERISTICS

Future fleet characteristics have been developed from discussions with various shipping agents, industry representatives and the Hilo Harbormaster.

Barge

Future barge traffic through Hilo Harbor will essentially remain unchanged, and no appreciable increase in vessel fleet or vessel size is anticipated. The only foreseeable change in the barge vessel fleet is the introduction of the new ITB vessel in 1982 and the proposed use of a 60,000 barrel barge.

The ITB is the largest oceangoing barge built in the United States. The new barge is non-self propelled with a specially designed stern for rigid connection to a catamaran tug for pushing. It has a dead weight capacity of 37,200 tons (DWT) and a design draft of 36 feet. Its overall length is just over 684 feet when coupled to the tug, and its beam is 84 feet. The ITB is designed to carry raw sugar, grain, granular fertilizers or similar cargoes in six holds. It is also equipped with four liquid fertilizer tanks, having a total capacity of 216,000 cubic feet.

The ITB will be used primarily to transport sugar from Hawaii to a refinery in California. It will make an estimated 16 trips annually. Routinely, the vessel will stop first at Hilo or Nawiliwili and then proceed to other ports along the Hawaiian chain to load sugar. The ITB will also be used to backhaul fertilizer approximately four trips a year.

Tankers

Continued use of the existing tankers is anticipated according to oil company representatives. Because of the limited demand and through-put capacity at Hilo Harbor, a trend towards the usage of large tankers is not envisioned at this time.

Dry Bulk Carriers

The ITB vessel and two other bulk carriers will handle future shipments of sugar beginning in November 1982. Since the production of sugar during the period of projection is expected to remain relatively unchanged, the required number of trips needed to transport this commodity will remain constant. No decision has been made concerning the handling of future molasses shipments.

Containerships

Continued use of the two existing containership vessels is anticipated over the period of projection, and an alternate vessel could possibly be used when additional trips are required for extra cargo. Containership vessels have been converting to the relatively new RO/RO type vessel because of more efficient operational capabilities with containerized cargo. Containerization of general cargo is becoming increasingly popular among local shipping companies.

Interisland Cruise Ships

There are only two interisland cruise ships presently in operation. Two other ships have been granted permission to serve Hawaii. One of these vessels, however, has had to postpone its scheduled start because of financial tie-ups and delays. The other vessel is scheduled for operation shortly.

A summary of the future vessel fleet serving Hilo Harbor is shown on Table 13.

Table 13. Future Vessel Fleet 1/2/

Company Vessel	Type	DWT	Loaded Draft (Feet)	Length (Feet)
Company No. 1				
Vessels A	Containership	4,400	18' 4"	338'
B	Containership	14,000	28' 1"	700'
Company No. 2				
Vessels C	Bulk Carrier	37,200	36' 0"	684'
D	Bulk Carrier	31,500	33' 10"	641'
E	Bulk Carrier	24,000	33' 8"	595'
Company No. 3				
Vessels F	Tanker	35,000	35' 8"	661'
G	Tanker	35,000	35' 8"	661'
Company No. 4				
Vessel H	Tanker	28,900	29' 5"	492'
Company No. 5				
Vessel I	Passenger Ship	750 passengers	23'	682'
Vessel J	Passenger Ship	750 passengers	23'	682'

1/ Companies and vessel names have been replaced with a number and letter to avoid disclosure of confidential information.

2/ Does not include barge traffic. There are seven companies using barges to Hilo.

PROJECTION OF VESSEL TRAFFIC

A projection of ships by user for Piers 1, 2 and 3 at Hilo Harbor (Table 14) was based on future incoming and outgoing tonnage through Hilo Harbor and on a two-year record of shipping trends available from the Department of Transportation, Harbors Division. A projection of vessels to each peir was made possible by obtaining the percentage split of cargo amoung users for that particular pier. A summary of all projected vessel and barge traffic through Hilo Harbor is shown on Table 15. Based on conversations with various local shipping agencies, the existing scheduled trips by each company was assumed to remain constant as long as the capacity of the vessel was not exceeded. For example, in the year 1985, it is anticipated that Company No. 10's barge will handle approximately 52,292 short tons through Hilo Harbor. Based on its existing schedule of 24 trips per year and the capacity of this vessel, future shipments can be handled through the year 2010. In 2030, however, 120,717 short tons are estimated for the barge. With a barge capacity of only 30,000 barrels or 4,200 short tons, four additional trips will be needed to accommodate the anticipated petroleum shipments.

Table 15. Summary of Future Vessel and Barge Trips to Hilo Harbor

Pier Year	Total Vessel and Barge Pier 1	Pier 2	Pier 3	Number of Vessels Per Trips to Hilo Harbor
1985	116	168	69	353
1990	116	170	76	362
2000	116	173	92	381
2010	117	176	108	401
2020	119	179	126	424
2030	123	182	146	451
2035	126	184	156	466

BENEFITS FROM BREAKWATER MODIFICATION

GENERAL

Potential benefits resulting from construction of a new inner breakwater and abandoning the 7,500 feet existing breakwater would accrue from maintenance reduction savings. Benefits can also be anticipated from tsunami and storm repair savings and savings from expected new works.

STORM REPAIR SAVINGS

Benefits resulting from an inner breakwater construction would accrue from storm repair savings. The average annual maintenance cost for the existing 10,000 foot breakwater due to periodic storm damages from 1930 to 1980 was approximately $20,000 per year or $2.00 per foot. Under the proposed plan only 2,500 feet of the existing breakwater will be maintained, resulting in significant storm repair savings.

Table 14 - Projection of Ships to Piers in Hilo Harbor by User

PIER 1

		Company No. 1 1/				Company No. 2		Company No. 3		Company No. 4	
		Vessel A2/		Vessel B3/							
Year	Total Cargo to Pier (short tons)	Total Cargo (short tons)	Trips	Total Cargo (short tons)	Trips	Total Cargo (short tons)	Trips	Total Cargo (short tons)	Trips	Total Cargo (short tons)	Trips
1985	315,500	117,262	26	117,262	52	170,000	15	30,975	20	50,000	3
1990	358,700	136,343	26	136,343	52	140,000	15	36,015	20	50,000	3
2000	429,200	167,480	26	167,480	52	139,000	15	44,240	20	50,000	3
2010	485,060	192,152	27 4/	192,152	52	138,000	15	50,757	20	50,000	3
2020	552,320	221,858	29 4/	221,858	52	137,000	15	58,604	20	50,000	3
2030	629,780	253,340	33 4/	228,800	52	136,000	15	67,641	20	50,000	3
2035	672,200	320,810	36 4/	228,800	52	136,000	15	72,590	20	50,000	3

PIER 2

		Company No. 5		Company No. 6	
Year	Total Cargo to Pier (short tons)	Total Cargo (short tons)	Trips	Total Cargo (short tons)	Trips
1985	177,000	13,275	12	163,725	156
1990	205,800	15,435	14	190,365	156
2000	252,800	18,960	17	233,840	156
2010	290,040	21,753	20	268,287	156
2020	334,880	25,116	23	309,764	156
2030	386,520	28,989	26	357,531	156
2035	414,800	31,110	28	383,690	156

Table 14 (cont). Projection of Ships to Piers in Hilo Harbor by User

PIER 3

Year	Total Cargo to Pier (short tons)	Company No. 7 1/ Total Cargo (short tons)	Trips	Company No. 8 Total Cargo (short tons)	Trips	Company No. 9 Total Cargo (short tons)	Trips	Company No. 10 Total Cargo (short tons)	Trips	Company No. 11 Total Cargo (short tons)	Trips
1980	255,800	158,596	24	10,232	9	20,464	6	23,022	3	43,486	24
1985	307,600	190,712	24	12,304	10	24,608	8	27,684	3	52,292	24
1990	366,200	227,044	27	14,648	12	29,296	9	32,958	4	62,254	24
2000	485,500	301,010	35	19,420	16	38,840	12	43,695	5	82,535	24
2010	601,800	373,116	44	24,072	19	48,144	15	54,162	6	102,306	24
2020	710,100	440,262	51	28,404	23	56,808	17	63,909	7	120,717	28
2030	818,000	507,160	59	32,720	26	65,440	20	73,620	8	139,060	33
2035	865,000	536,300	63	34,600	28	69,200	21	77,850	9	147,050	35

1/ Company and vessel name has been replaced with a number and letter to avoid disclosure of confidential information.

2/ Vessel A will be making only 26 trips per year to Hilo. Any additional trips required for extra cargo will be handled by its sister ship. Vessel A currently carries 50% of its cargo to Kahului and the remaining 50% to Hilo.

3/ Vessel B will be making 52 trips per year to Hilo. Any residual cargo will be handled by an alternate vessel.

4/ Ship projections include the estimated number of trips to be made by the sister ship.

TSUNAMI REPAIR SAVINGS

Five major tsunamis (1946, 1952, 1957, 1964) have occurred in Hilo since the original breakwater was completed in 1930. The 1946 tsunami, with a wave height of 27 feet at the breakwater, was the most destructive in terms of monetary losses. The Hilo breakwater was severely damaged with repair costs totalling $14,419,000 (October 1982 price level).

Abandoning 7,500 feet of the existing breakwater will result in benefits accruing from tsunami repair savings. A study completed by the Pacific Ocean Division in 1967 titled, "Hilo Harbor Tsunami and Navigation Protection," estimated that major tsunami damage would occur at least once every 50 years on the average. Total damage was estimated to be in the range of $8,900,000 (1982 price level) or about $178,000 annually. Based on the estimated annual damages for the 10,000-foot long existing breakwater, the unit cost savings per foot from tsunami repair work will be $17.80.

COST OF NEW WORK

Existing Breakwater (Without Project Condition). The existing Hilo breakwater, completed in 1930, is currently being upgraded to improve structural stability. Work has been completed on 900-foot portion of the main breakwater at a cost of about $2,500 per foot (1982 price level). Future improvements for Hilo Harbor include the eventual repair of the entire existing Hilo breakwater. Construction costs on the remaining outer portion of the breakwater will be higher because of greater size and water depths. A higher unit cost of $3,400 per foot was used in cost evaluations for the remaining outer portions of the breakwater repairs. It was assumed that these repairs would be completed incrementally at a rate of 2,300 feet per year beginning in 1985. With about 9,100 feet of the remaining 10,000-foot existing breakwater to be repaired, repair works would be completed within 4 years. Based on a discount rate of 7-7/8 and a 50-year period of analysis, the average annual cost for major repair work on the existing Hilo breakwater is estimated at about $2.3 million.

New and Existing Breakwater (With Project Condition). Under the with project condition, a new 2,000-foot inner breakwater will be constructed and merged with 2,500 feet of the old existing Hilo breakwater. Since 900 feet (between Sta. 11.00 and 20.00) of the existing breakwater will already have been completed by 1983, the average annual repair costs for the existing breakwater was taken for only 1,600 feet. Based on a unit cost of $2,200 per foot for the inner 1100 feet and $3,400 for the outer 500 feet, the average annual repair cost for this portion will be $332,000. The estimated average annual construction cost for the proposed inner breakwater will be $1,135,000. The combined annual repair and construction cost for both the new inner breakwater and the 1600 foot section of the existing breakwater is estimated at $1.467 million. Average annual costs are based on a discount rate of 7-7/8% and a 50-year period of analysis.

SUMMARY

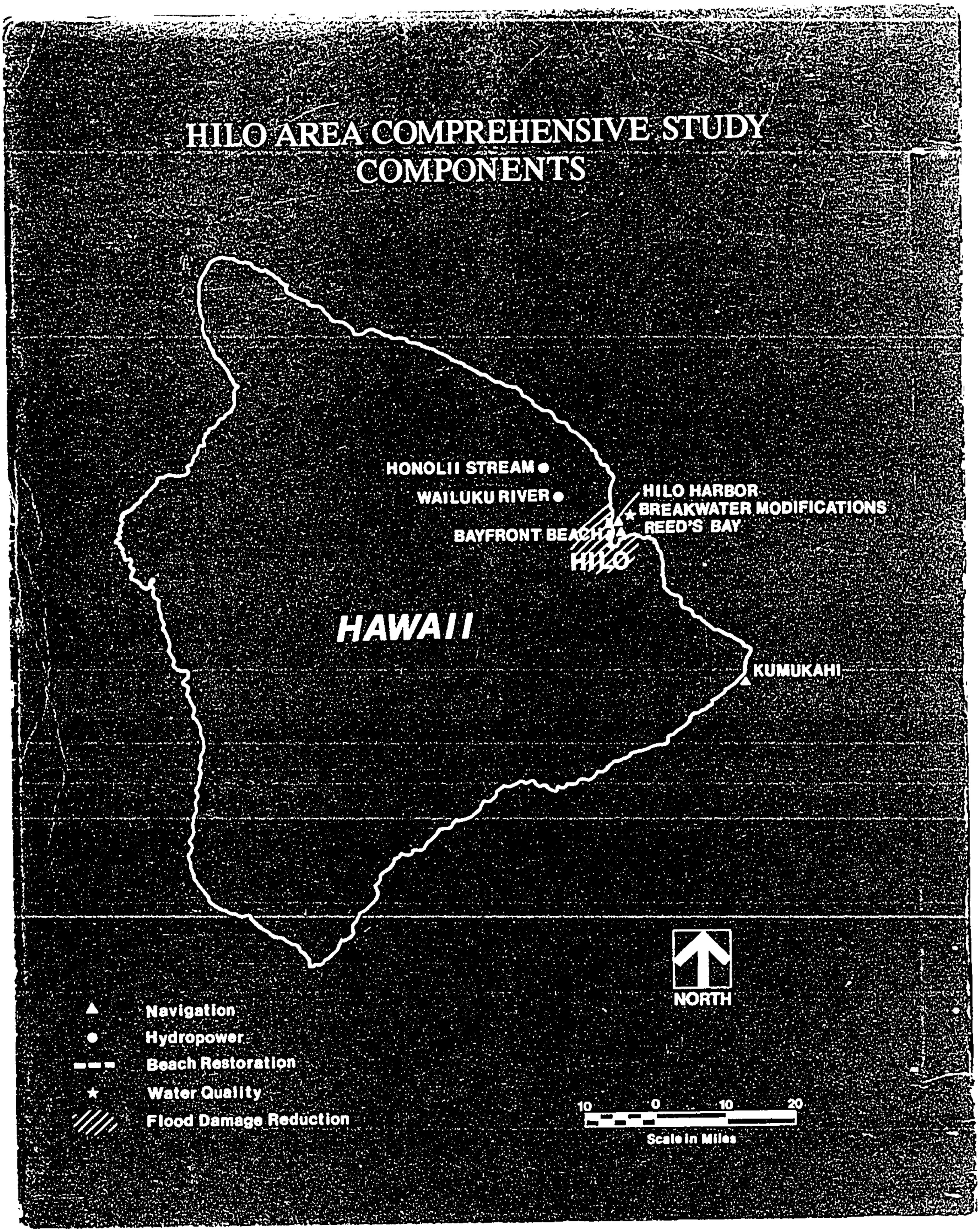
The construction of a new 2,000-foot inner breakwater would be as effective as the existing one. The benefits measured as the difference in costs of storm and tsunami repair and new work with and without the proposed modification results in a net annual savings of $2,064,500. Table 16 summarizes the costs with and without the proposed inner breakwater.

TABLE 14

SUMMARY OF BENEFITS

Average Annual Cost Incurred Under Without Project Conditions 1/				Average Annual Cost Incurred Under With Project Conditions 1/			
Storm Repair				Storm Repair			
\$2.00/ft	10,000 ft	=	\$20,000	\$2.00/ft	2500 ft	=	\$5,000
					2000 ft 2/	=	800
Tsunami Repair:				Tsunami Repair:			
\$17.80/ft	10,000 ft	=	178,000	\$17.80/ft	2500 ft	=	44,500
					2000 ft 2/	=	7,200
New Work:				New Work:			
Major Repairs			2,256,000	Major Repairs			332,000
Total			\$2,454,000	Total			\$ 389,500

1/ Based on a 50-year service of analysis and a discount rate of 7-7/8%.
2/ Storm and tsunami damage repair applicable to the new 2000-foot inner breakwater after an estimated 20 years when substantial deterioration of the main breakwater occurs.



HILO AREA COMPREHENSIVE STUDY
COMPONENTS
HONOLII STREAM
WAILUKU RIVER
HILO HARBOR
BREAKWATER MODIFICATIONS
REED'S BAY
BAYFRONT BEACH
HILO
HAWAII
KUMUKAHI
NORTH
Navigation
Hydropower
Beach Restoration
Water Quality
Flood Damage Reduction
10
0
10
20
Scale in Miles